THE

VETERINARY JOURNAL

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THE KING'S CALL TO HIS PEOPLE

PUT into your task, whatever it may be, all the courage and purpose of which you are capable. Keep your hearts proud and your resolve unshaken. Let us go forward to that task as one man, a smile on our lips, and our heads held high, and with God's help we shall not fail.

From the speech made by His Majesty The King and broadcast to the British Empire on Empire Day, May 24, 1940

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Editorial

THE VETERINARY PROFESSION AND THE WAR

We publish in this and the next issue of The Veterinary Journal a paper of considerable importance. It deals with the subject of Air Raid Precautions for Animals. Some damage from enemy action has already been done to livestock and, in each instance, the veterinary profession has made its contribution to the treatment of the injured animals.

Up to the present time the veterinary profession has not been employed directly, to any large extent, in war activities. The great service which it rendered to the country in the Great War (1914-1918) cannot be used on this occasion for the complete change of the essential methods of warfare have, to a very large degree, cut out the use of horses and mules.

There are, however, other uses to which the training and experience of the profession can be put. The paper, referred to above, concerns one of them—the services to be rendered to animals in the event of enemy action causing damage to them, especially air raids. The organisation of the National Air Raid Precautions for Animals Committee is essentially dependent on the veterinary surgeon. Whether it be the small household pet or the larger type of livestock which may be involved, the maximum amount of skilled treatment and advice must be forthcoming at the earliest possible moment. In all such work, members of the veterinary profession must play an essential part. It is with much satisfaction that we heartily endorse the work of that Committee in the various branches of the work which it is undertaking. Its task is far-reaching and may be strenuous, but we are convinced that with the full support and collaboration of the veterinary profession, its organisation will, if and when required, carry out its duties in such a way that no animal will suffer more than can be avoided and that the salvage of animal carcasses will be done wherever possible to the benefit of the country and the farming community.

The veterinary profession must also play an important part in the conservation of health and the prevention of disease in livestock. In these days when the food supply of the country is of such value to the nation, the health and disease of livestock are more than ever of first importance. The veterinary surgeon, because of his training and experience, must control the health of our animals and it is essential that schemes be brought into being at once to ensure that the whole of the available knowledge at the disposal of the veterinary profession be used to the greatest possible advantage.

General Articles

AIR RAID PRECAUTIONS FOR ANIMALS

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THE chief objects of air raid precautions for animals are:

(1) The prevention and alleviation of animal suffering.
(2) The protection of human beings from panic-stricken or gas-contaminated animals.
(3) The conservation of animals of economic value.
(4) The provision and protection of food supplies for essential animals (transport and farm animals).
(5) Giving general information and advice to animal owners.

It is essential that in dealing with this subject reference be made to precautions for human beings because workers must know how to protect themselves in order that animal casualties can be dealt with in an efficient manner.

The experience gained from the wars in Spain, Finland, Norway and on the Western Front indicates that the most serious method of attack from the air is by means of the bomber.

Methods of attack by bombers are mainly:

(1) Bombing by machines flying at a high altitude, say, 10-20,000 feet.
(2) Aircraft flying at a high altitude, and then nose-diving and releasing bombs at a low altitude.
(3) Gliding. Aircraft proceed to a location, say the coast, at a high altitude, shut off their engines, and silently glide down to the objective where the bombs are dropped or gas is sprayed.
(4) Bombing or machine-gunning from low-flying aircraft.
(5) Spraying gas from low-flying aircraft.

Of these, the last two are most suitable for country districts and poorly defended places.

There are three main types of bombs: high explosive, incendiary and gas.

HIGH EXPLOSIVE BOMBS are very similar to shells except that a shell which has to be projected from a gun has to be enclosed in a fairly heavy and substantial case or shell in order to withstand the impact of the initial explosive discharge, whereas a bomb need not be protected except by a thin shell or case just sufficiently strong to hold the contents. By making the outer casing lighter, much more explosive can be carried in a bomb.

High explosive bombs can be of three main types:

(a) with an armour-piercing nose;
(b) with semi-armour-piercing nosepiece (such bombs penetrate when they strike an object and are fitted with a delayed action fuse, so that they do not explode immediately, but only after reaching their maximum depth of penetration);
(c) a simple or contact high explosive bomb, exploding immediately it makes contact with its objective.

High explosive bombs are of various weights, usually from about 50 to 500 lb., but it is possible to make them up to 3,000 lb. in weight. Very heavy high explosive bombs are more especially of the armour-piercing type.

An armour-piercing bomb will go through the reinforced concrete of any normal building and may penetrate to the basement. Apart from the penetration, two further points are important:

(i) Fragmentation of the bomb case. This has the same effect as shrapnel. Pieces of wreckage may also be thrown all over the place.

(ii) The blast or wind set up by the explosion of the bomb. Although brown paper, cellophane, etc., pasted over windows may prevent glass being splintered by blast, a very heavy bomb exploding within, say, 50 yards of a building may create sufficient blast to wreck it entirely. In the case of a reinforced concrete building the walls might collapse and so leave the steel structure.

A high explosive bomb on explosion sets up a violent impulsive pressure or blast lasting for 1/10,000th part of a second and also sends splinters hurling in all directions. Blast waves rise as they spread outwards. Splinters also spread outwards, but the majority fall within a line drawn at 15 deg. to the line of impact. If the bomb penetrates, and all do to some extent, even the non-armour-piercing type, then the line of the angle will be lowered accordingly. In order to resist the impact of splinters from a 500-lb. high explosive bomb bursting within 50 ft., protection afforded by a mild steel plate 1½ inches thick, reinforced concrete 12 inches thick, solid brickwork 13 inches thick on earth works 2 ft. 6 in. in thickness is necessary.

Only well-built underground buildings suffice against direct hits by high explosives, but the construction of such buildings is not likely to be entertained on account of the initial expenditure involved.

The use of sandbags or earth works to protect walls, break the blast and lessen the danger from splinters is indicated; wooden boxes filled with earth are a suitable substitute for sandbags. The outside of glass windows may be protected from splinters by wire netting and the inside covered with a double layer of cellophane applied by means of cellulose varnish. Failing cellophane, thin linen or stout paper will give some protection, but is much less effective.

Unless the walls are more than a foot thick, sandbags will be required to protect them against splinters and blast. The thickness of sandbags required will depend on the wall thickness and can be determined by the consideration that the total thickness of the wall and sandbags should be equivalent to 2 ft. 6 in. of sandbags, 1 ft. of brickwork or concrete being taken as equivalent to 2 ft. 3 in. of sandbags. Thus a 4½ in. brick wall would require a sandbag wall 10 in. thick. If the stable wall is of timber the sandbag wall should be the full thickness of 2 ft. 6 in. Care should be taken in building the sandbag wall to ensure that it does not exert a pressure on the stable wall greater than the latter can withstand. A properly built sandbag wall should be capable of standing alone with relatively little support from the stable wall.

Steel helmets provide some degree of personal protection against the effects of flying missiles, machine-gun fire and splinters from anti-aircraft shells.

High explosive bomb injuries to persons and animals are the ordinary injuries associated with modern warfare.

THE INCENDIARY BOMB is usually quite small and its object is to cause fires. The average bomb does not weigh more than a kilogramme (about 2 lb. 2 oz.), but, of course, larger incendiary bombs can be made. They have very little penetrating effect. Roofs made of 6-in. reinforced concrete are quite safe against the average incendiary bomb, but it will penetrate any ordinary roof, and might go through the roof and rest on the top of the ceiling. This is one of the most dangerous properties of light incendiary bombs.

Incendiary bombs are composed of a fuse with a centre core of material which generates great heat, igniting the surrounding cylinder of a magnesium alloy.

In all, some 1 to 1½ lb. of magnesium may be contained in the bomb. When one compares this amount with the small strip used in taking a flashlight photograph, some idea of the effects of the incendiary bomb can be realised. It will naturally cause the roof to take fire. One of the greatest dangers from the air raids which occurred in Finland has been these bombs, each of about 2 lb. in weight. A bomber can carry a large number and fires can be caused in different parts and in several buildings at the same time, giving rise to much damage and confusion.

Incendiary bombs inflict damage on buildings and thereby cause injury by burns to human beings and animals. If a piece of burning magnesium comes in contact with a living body, a very severe burn will result. One of the unfortunate things about an incendiary bomb is that it often splutters while it burns and throws out sparks. This spluttering is increased if attempts are made to put them out with water from a hosepipe or bucket.

The use of water on an incendiary bomb should be by means of a fine spray, as from a stirrup pump, which will tend to extinguish and limit the

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danger of the fire from spreading to surrounding parts. To deal with such bombs A.R.P. services are provided with sand, incendiary bomb shovel and scoop. An ordinary small shovel that has a long handle, say six feet long or longer, will be found useful. Incendiary bombs burn very brightly and it is wise to wear dark glasses while looking at them. Throwing sand over an incendiary bomb limits its effect on the surrounding parts and tends to suppress the spluttering.

To deal with incendiary bombs, an incendiary bomb shovel and scoop with long handles and adequate supplies of sand or fine soil should be provided at convenient points and the water supplies clearly indicated. Receptacles filled with sand or earth should be made essential adjuncts to every stable, cowshed, etc. Buckets kept filled with water should also be available. Horses and cattle should have head stalls fitted with quick release devices or slip bolts so that they may be set free quickly in an emergency. Objects which might impede the rapid exit of animals from buildings should on no account be placed near to doors or other openings which might serve as emergency exits.

Stacks should not be erected around buildings, but preferably in open fields and as far apart as possible, but in no case less than 40 ft. Forage, bedding or other inflammable materials should not be stored in lofts, but should be placed in separate buildings away from animals.

Fire extinguishers are of very great use in dealing with fires, but they should not be used in an attempt to extinguish the incendiary bomb itself, otherwise poisonous vapours may be generated.

It must be borne in mind that the roofs of many stables and cowsheds in the country are thatched and that the water supply of farms is often scarce and far removed, so that it is most essential for every possible provision to be provided on the spot ready at hand to meet any emergency.

GAS BOMBS.—These are dropped like ordinary high explosive or incendiary bombs. They can be used with much more accuracy than spraying, but, of course, their effect is localised. They are most likely to be used in towns.

Gas can also be used in the form of spray. The ordinary bomber is used, the bomb rack being removed and replaced by a container for the gas, which is sprayed out on to the object.

SPRAYING is not likely to be used in towns because a great deal of gas would fall on roofs, etc., and fail to find its objective, hence spraying is more likely to be used in country districts or on open spaces where people or animals are congregated. In the case of *gas spraying* the area contaminated will depend on the altitude of the airplane at the time of discharge. The higher the altitude the finer will be the spray and so a relatively larger area will be lightly contaminated, whilst at low altitude a small area will be more heavily contaminated and the drops of liquid gas will be larger. If the airplane is

flying with the wind, a long narrow area will be contaminated, whilst if the machine is flying against the wind the area contaminated will be shorter and broader (egg-shaped).

THE TERM GAS is meant to imply any substance, whether it is a liquid, true gas or a solid; in fact, any substance used for its deleterious effect on the animal or human population.

" Gases " may be either finely divided solids, like nasal irritant gases, true gases, as are phosgene and chlorine, or liquids, such as the blister gases. All gases are treated in such a manner that prior to discharge they are either in a solid or liquid form. True gases revert to their gaseous state when released.

Liquid gases may inflict injury directly or by means of the vapour which is given off. If liquid blister gas comes into contact with any part of the body severe local injury results, and when it is evaporating the vapour is highly injurious.

Gases are divided into four main classes with regard to their effects on the body.

TEAR GASES are used merely for their panic-producing effects. They do not cause any permanent harm. They merely cause panic and lower the morale of the population. Tear gases cause smarting and watering of the eyes which may be so great that one cannot see anything. They only cause temporary inconvenience.

Tear gases have no effect on animals. Their only effect is on the human population, so that from the animal point of view we need not worry about them. These temporary effects may render the personnel incapable of dealing with their duties. Adequate protection is therefore essential.

NASAL IRRITANT GASES cause an unpleasant smarting sensation in the nose and throat. They also cause tears to flow and watering from the nose. If one has been subjected to even a low concentration of these gases for any length of time headache and aching of the teeth and gums develops. Fortunately this wears off after a time in fresh air.

Nasal irritant gases also have practically no effect on animals, and horses are capable of work almost immediately on being removed from exposure to the nasal irritant gases.

CHOKING GASES were the first gases to be used in the last war. Chlorine and phosgene are typical examples. They can produce prolonged illness, perhaps death, but more likely the former. Even after recovery the victims may be left with a hard, hacking cough, denoting chronic bronchitis. Chlorine is largely used in commerce, as is phosgene, which is very extensively used in the dyeing industry, consequently these gases are easy to obtain without the need of especially erected plants.

BLISTER GASES.—These are the worst of all gases. There are two common blister gases—mustard gas and lewisite. They act either by contact of the

liquid or by the gas given off by the liquid. They attack *all* parts of the body with which they come into contact.

Gases can again be divided into two classes according to whether their effect is transitory or whether the effect persists in the locality contaminated by them, i.e., persistent and non-persistent gases. Obviously the true gases are not persistent. They can be blown away by wind and dispersed into the atmosphere. Non-persistent gases are true gases from the chemical point of view. Not only are the true gases non-persistent, but so also are the nasal irritant gases, the fine smoke particles of which float about in the air. The persistent "gases" are the liquids and they are all of them oily liquids.

PERSISTENT GASES are those that contaminate the surroundings and continue to give off poisonous vapour for a considerable time. They are liquids when discharged. The blister gases, like mustard and lewisite, persist for long periods, continuing to give off poisonous vapours from the objects contaminated for, perhaps, weeks under certain conditions. The tear gases known as K.S.K. and B.B.C. are also persistent gases, but their persistency is short as compared with the blister gases. K.S.K. may persist for hours, whilst B.B.C. may continue to give off vapour for days. Both are liquids.

NON-PERSISTENT GASES are those which, when liberated, are converted into true gases or smokes and continue to be effective only so long as they remain at a sufficiently high concentration. They cease to be effective when blown away by the wind or when well diffused into the surrounding atmosphere. They comprise the tear gas C.A.P., the nasal irritants and the choking gases.

Meteorological conditions affecting the behaviour of gases.—Non-persistent gases and the vapours given off by persistent gases are affected by the wind. In dead calm weather the gas will remain in high concentration near the point of discharge and so a relatively small area only will be affected, but in high winds the gas will soon be blown away and become diluted until the concentration becomes harmless. Winds blowing between 5-12 miles an hour are the most dangerous during a gas attack. Bright sunshine causes ascending air currents and so carries the gas upwards. Warm temperatures are also beneficial in this respect. In normal daytime conditions the air currents are ascending, but at dawn and dusk the air is stationary, apart from winds, whilst during the night there are descending currents of air. During night time and at daybreak and nightfall, conditions are more favourable to the enemy for gas attacks than during the day.

Fogs, mist, low-lying clouds and very light rains tend to keep gases down and prevent their upward dispersement, hence such conditions aid the effectiveness of gas attacks.

Flat, open country allows quicker dispersement of gases than wooded, uneven ground; built-up areas and enclosed spaces provide "pockets" for the

collection and protection of gases. Basements in buildings may be particularly dangerous in this respect. Heavy rain washes the gases out of the atmosphere and also helps to render many gases inert (especially the blister gases).

In the case of persistent gases the higher the temperature the greater will be the concentration of vapour given off but the shorter will be the duration of persistency. Wind will also aid evaporation of the persistent gases. In very low temperatures persistent gases evaporate very slowly. They may therefore persist in sufficient strength to cause trouble as the temperature rises again. Heavy rain will wash away the persistent gases which, being heavier than water, will sink below the surface of streams, ponds, etc., and be rendered inert by hydrolysis—this action is slowest in the case of mustard gas.

THE NATURE OF THE MATERIALS CONTAMINATED by the persistent gases will also have a bearing on the effects produced. Glass glazed tiles and clean and polished metals are impervious to the blister gases which penetrate other materials, as ink does into blotting paper. The longer decontamination is delayed the greater will be the degree of permeation. When permeation has occurred the gas is protected from factors operating whilst it is free and so it will remain dangerous as it slowly evaporates or until it is hydrolysed or methods of decontamination are applied. The latter are naturally less effective once the gas has been absorbed by some pervious material.

DESCRIPTION AND ACTIVITY OF GASES.—Most gases are very complex chemical substances, and in A.R.P. matters it is usual to denote many of them by letters.

The three TEAR GASES are known as C.A.P., K.S.K., B.B.C.

C.A.P. (chlor-aceto-phenone) is stored in the form of a whitish solid, but as soon as it is released from pressure it becomes a true gas and is non-persistent. It is odourless and invisible and the only way it may be recognised is by the fact that it produces a smarting of the eyes and lacrymation. It may cause some slight irritation to sensitive skins.

K.S.K. (ethyl-iodo-acetate) is a dark brown, oily liquid and is slightly persistent. It has a very typical smell of pear drops so that it can be detected by smell apart from the smarting effect on the eyes. It is persistent—if a bomb were dropped into a room the gas would splash the floor, and if the windows were opened the concentration would very rapidly fall, though the gas could still be detected after an hour or more. Under such conditions and especially if there were a little wind, non-persistent gases, like C.A.P. would soon disperse.

B.B.C. (bromo-benzyl-cyanide) is a yellow liquid with a bitter sweet smell. It is also slight persistent, and rather more so than K.S.K. It may persist for a day or more under certain conditions.

THE NASAL IRRITANTS are complex forms of arsenic. They are all fine particulate solids. D.M. (di-phenyl-chloro-arsine) is yellow in colour, whilst

D.A. (di-phenyl-amine-chlor-arsine) and D.C. (di-phenyl-cyano-arsine) are colourless or whitish. They are solids at ordinary temperature, but when heated or exploded from bombs form an almost invisible smoke.

Neither tear nor nasal irritant gases have any marked effect on animals—they are only important to the animals on account of their effects on the attendants.

THE CHOKING OR LUNG IRRITANT OR ASPHYXIANT GASES attack the lining membranes of the respiratory tract, the more pronounced effects being on the small bronchial tubes and air spaces in the lungs. They also cause some watering of the eyes.

Chlorine is a true gas, has a yellow-green colour and a characteristic smell. Bleaching powder owes its odour to the fact that it liberates chlorine gas in minute quantities. The immediate effects of chlorine on animals are irritation of the throat and coughing. It attacks the lungs and may cause bronchitis and pneumonia, and even collapse, followed by death.

Phosgene is a true gas which even in very small dilution has a smell like decaying vegetable matter or musty hay. In acute cases in animals slight spasms of coughing may or may not occur, and, owing to the delayed action of this poison, symptoms may not develop until 12 or 24 hours after exposure. Breathing becomes hurried and difficult, the nostrils widely dilated, temperature rises, and there is a nasal discharge, at first foamy, but later becoming thick and bloodstained. Death may occur by the 48th hour. In milder cases the patient has a general appearance of depression, eyes staring, nostrils dilated, hurried breathing and a slight rise in temperature. There is a tendency to cough. Recovery takes place in from 4-6 days.

Di-phosgene has an odour similar to phosgene. It is an oily liquid which gives off a vapour like phosgene and causes greater watering of the eyes. Phosgene and di-phosgene are much more injurious than chlorine, and in addition to the irritant effects on the lungs they cause an outpouring of the tissue fluids into the lungs, producing, in effect, a state of drowning. A period of comparative well-being may be experienced for an hour or so after exposure to these gases, but this is followed by pronounced illness and perhaps collapse.

Chloropicrin is a yellow liquid which has an odour similar to that of chlorine. It is the most irritant of all the gases in this group. It is also cumulative in action and frequent exposure to it increases the response evoked by the animal body.

BLISTER GASES.—There are two blister gases which are likely to be used in war—mustard gas and lewisite. **Mustard** (di-chloro-di-ethyl sulphide) was used very effectively in the last war. It was first used at the battle of Ypres and was so named Yperite by the Allies. The Germans called it "Yellow Cross." It is known as mustard gas because it has a rather faint odour like

mustard, but some people consider it to be more like horse-radish, onions or garlic.

Lewisite (chloro-vinyl-di-chlor-arsine) was invented in 1918 by the American chemist Lewis. All we know about lewisite is the effects that have been produced experimentally for, so far, it has never been used in war. Mustard gas and lewisite are the most persistent of the known war gases. They are in the form of liquids and do damage if the liquid comes into contact with the skin which, in man, will blister. Damage is also caused if the vapour comes into touch with the eyes, lungs or skin. Lewisite is the more dangerous and acts more quickly than mustard gas. Its action is very pronounced and this helps in its recognition.

It is usual to group *the properties of* **mustard gas** under ten headings: Insidious action, universal action, cumulative action, persistency, penetrative powers, dual action, solubility, stability, delayed action, respirator protection.

Insidious action.—Mustard gas has only a faint odour, hence the vapour may cause damage in a low concentration without its presence being recognised. Severe damage may be caused even in the dilution of one part mustard gas in a million parts of air. The ability to recognise the odour passes off after one has been exposed to it for a while. This may lead one to assume that the danger has passed when it is still existent.

Universal action.—The gas affects any part of the body with which it comes into contact. Tear gases mainly affect the eyes, although some may cause a little temporary discomfort if they come into contact with the very thin parts of the skin. The nasal irritants only affect, to any appreciative extent, the nose; the lung irritant gases affect the lungs, but blister gases affect any part of the body with which they come in contact. If one breathes the vapour of mustard gas it will have an irritating effect upon the lungs. This also applies to lewisite. Irritation of the lining of the lungs may give rise to bronchitis and pneumonia. If the liquid comes in contact with the skin, blistering takes place. If it comes into contact with the eyes permanent damage may result, whilst if the vapour comes into contact with the eyes temporary damage is caused.

Cumulative action.—Exposure for a short period to high concentration of mustard or lewisite vapour causes the parts of the human body which are affected to become severely inflamed. Contact with very low concentrations of mustard gas will cause redness and inflammation of the skin, but prolonged exposure to the gas may cause the same results as a short exposure to a high concentration.

Persistency.—The blister gases are very persistent. If an area is heavily contaminated with liquid mustard gas it may remain a source of danger for a period as long as three weeks under normal weather conditions, especially if the contaminated area is protected from the direct action of wind and sunlight. Obviously persistency is directly related to the degree of contamination.

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Penetrative powers.—Mustard and lewisite penetrate all materials with the exception of glassware, porcelain, glazed tiles and polished, metallic surfaces. They penetrate the bare skin relatively quickly and dissolve in animal fats. Mustard gas soaks through the skin, dissolves into the fatty tissues under the skin and spreads out like a blob of ink on blotting paper. The degree of penetration depends to a large extent on the nature of the material contaminated. It will penetrate into leather, woodwork, brickwork, etc. The harder the material the fewer holes in it and the less porous it is, the less will be the depth of penetration. The degree of penetration has quite an important bearing on the persistency of the gas, because if the gas is spilled on a highly polished metallic surface or glass, the chances of its evaporating will be much greater than if it soaks into brickwork. It penetrates easily into clothing. Liquid spilled on the clothes will penetrate and the heat of the body will cause it to vaporise.

Dual action.—Mustard and lewisite have dual action. They can cause injury in both the liquid and vapour form.

Solubility.—Both blister gases are soluble very readily in fats, especially animal fats, spirits, paraffin oil, petrol, and things of that type. Lewisite is not soluble in water, whilst mustard gas is very slightly soluble in water.

Stability.—Mustard gas is very stable and once it comes in contact with material it maintains its activity for a long time unless decontamination is carried out. Water has a destroying effect on the blister gases. It splits them up by hydrolysis. There is not likely to be great danger of contamination of water by mustard gas. It is relatively insoluble yet when it gets into water it is hydrolysed slowly and so becomes innocuous. Lewisite is very unstable in the presence of water. It is very quickly broken down by water. If the water has a little caustic soda or any alkali in it, the hydrolysis is hastened. Mustard gas is destroyed by oxidising agents. One of the best agents to decompose mustard gas is nitric acid, but this is not a convenient substance to use, because of its destructive and caustic action. It will even penetrate concrete in time. Bleaching powder is a most convenient decontaminating agent.

Delayed action.—One of the most characteristic properties of mustard gas is its delayed action. Lewisite comes under the same category, but its action is not so delayed. By delayed action is meant that if a person or animal is contaminated the effects will not be noted for some time. If a splash of mustard gas gets on the human skin a reddening will appear, probably within two hours. Blistering will not occur until several hours later, depending on the size of the splash and other factors, such as the temperature and the condition of the skin. The presence of perspiration will aid the solubility of the blister gas and effects will be produced more quickly than on a dry, cold skin. If conditions are not favourable the delay in action of the liquid or vapour may be anything from 2-48 hours. Having regard to the fact that it cannot be recog-

nised very easily, the delayed action increases the insidiousness of mustard gas, for a person may be splashed and not realise it until 48 hours later. The exception to this delayed action is in the case of the eyes, there an immediate effect is produced.

Lewisite.—The blistering and other effects of lewisite are produced within three hours of contamination. Lewisite is not insidious because it has a smell of geraniums. An interesting point which is not likely to arise in this country is that when lewisite is first liberated into an absolutely dry atmosphere there is no smell, for it is odourless until it comes in contact with the moisture in the air. It has a universal action exactly the same as mustard gas and is also cumulative. The respirator gives protection only to lungs and face. Its persistency is much shorter than mustard gas, for it is quickly hydrolysed in water. The penetration of lewisite is even greater than that of mustard gas. As this gas penetrates more readily than mustard gas, first aid treatment will have to be applied with greater speed. When dealing with lewisite contamination of animals, however, speed is not so essential, for in their case the penetration is not so rapid as is that of mustard gas.

Respirator protection.—The respirator, either civilian respirators issued by local authorities to all civilians, or civilian duty respirators issued to Air Raid Wardens, or the general service respirators issued to the fighting troops and to the police and fire services, give complete protection against any of the known war gases likely to be used, so far as face and lungs are concerned. For tear, nasal irritant and lung gases, the respirator gives complete protection. But with regard to mustard and lewisite, the respirator only gives protection to the eyes and lungs.

Ordinary clothing will soak up liquid gas and give some protection to the underlying parts provided it is removed as soon as possible after contamination, but if contaminated clothing is worn for a period severe injury may result. Attendants likely to come into contact with animals contaminated with the liquid blister gases should be provided with suitable clothing. The clothing should be removed as soon as possible after use, and unless the degree of contamination is of a very light or localised nature, all clothing should also be removed. Clothing can be rendered harmless immediately by decontaminating by boiling in water or it may be put on a line to air for several days and thus decontaminate by weathering. The decontamination of premises, etc., will be carried out by the local A.R.P. decontamination squads, who are specially trained for this work. Bleaching powder and water are the agents used. Vehicles which have been used for contaminated materials and animals or carcases may be decontaminated by coating them with bleach paste, which is left on for ten minutes and then washed off, or by means of the liberal application of hot water or by hosing down with cold water for at least half an hour.

(*To be continued.*)

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IRIDO-CYCLITIS (Ophthalmitis) AMONGST ANIMALS AT WAR

(Continued)

By LT.-COL. HERBERT GREENFIELD, O.B.E., M.R.C.V.S.
Camberley.

Symptoms

Onset.—One of the problems for elucidation in iritis is its onset. Most writers are of the opinion that the disease arises suddenly and abruptly. The experience of the author is the reverse.

By regular inspection of the eyes of all horses in a regiment seriously affected in South Africa it was discovered that, prior to the recognised onset of ophthalmia, the iris showed slow changes, lack of colour, movement or dilation, and that a case might be foretold a month in advance of the usual clinical symptoms. Frequently there were lesions, old healed ulcers of the cornea, etc., in the affected eye or in the opposite one.

Of 49 cases definitely recorded at that time, 70 per cent. had such positive symptoms, 10 per cent. were doubtful, while 20 per cent. appeared to be negative in this respect. History of previous eye trouble appeared to confirm this at times, the horse being reported as seeing badly at night, starting to shy or stumble or occasionally to rear over backwards.

A very valuable polo pony, owned and ridden constantly by the writer, developed these symptoms—rearing over backwards, night blindness, and turgid, non-dilating pupil—and eventually developed acute iritis and became blind.

Careful scrutiny of " fresh cases " and " sudden onsets " during the past 20 years has often revealed sequelæ of previous disease such as streaky leucomata, low tension, evidence of organised synechia, pigment on the lower posterior surface of the cornea, and triangular drooping of the upper eyelid.

The observations concerning night blindness were amply and fully confirmed amongst the camels in Waziristan in 1921 (see " night blindness ").

There is reason to believe that a large number of sudden, abrupt onsets are recurrences, and that the disease is essentially insidious and progressive from its origin.

Bayer[6] holds a somewhat similar view and quotes Swarzenecker as carrying out long-continued eye inspections, like the author, with this point in view, and being confirmed in the opinion herein described. Other observers state that periodic ophthalmia apparently follows a case of superficial eye disease after a varying period. Wastage from the disease was reported as

heavy in the French Army by Nicolas when the importance of eye diseases was so little recognised that few, if any, affected animals were treated in hospital. Similarly, during war there is an ideal situation for the non-observance of or proper care being given to premonitory symptoms which may be premonitory causes.

Stress is laid upon this point as it is considered of importance; the immediate circumstances attending the occurrence of iritis are not necessarily the causative ones as has so frequently been believed. Little definite information on this subject is forthcoming from human ophthalmology. Fuchs[7] says that syphilitic iritis generally develops within the first year of infection, while metastatic iritis from relapsing fever sets in some weeks or months after the last attack of fever.

It is not intended to describe in full the classical features of the symptoms of iritis, but only to give prominence to those clinical signs which are essential to a consideration of iritis as a war disease.

The essential and differential symptoms of the disease when established are the contraction and immobility of the iris and the opacity of the aqueous humour. There may or may not be distinct density of the cornea; commonly when the cornea is affected it is " smoky " or brownish in tinge. It is rarely that there occurs a widespread milky opaqueness.

As soon as uveal inflammation becomes pronounced there is a rapid exudation into the aqueous, which immediately loses its transparency. The consequent opacity gives a very distinctive sign when examined by focal illumination: the light, being absorbed by the unusual particles in the aqueous, shows as a white beam from the cornea to the lens. This is easy to see and is diagnostic of iritis.

As far as it is known this has not been recorded in veterinary literature, and as a consequence iritis has not been recognised sufficiently early, either in the research on the disease or in its diagnosis.

With the development of inflammation the effusion increases and tends to be deposited at the bottom of the anterior chamber. There it assumes the appearance of pus and is called hypopyon. Often the exudate is intense and is almost a characteristic of iritis in the horse. Sometimes the fibrin in it floats as flocculi; in other cases it is deposited at the bottom and round the walls, producing a greyish-yellow tinge in the lens, iris and cornea, particularly in the lower parts. It is common for the fibrin to adhere to the pupil and to the lens, and it is often so extensive as to appear like a waterfall pouring through the pupil. Sometimes hyperæmia also exists.

Hypopyon is made up from the elements of exudation, like all inflammatory fluids, and contains desquamated cells from affected membranes (epithelium and pigment from the iris and ciliary bodies) and a considerable number of leucocytes, especially polymorphonuclear ones, which suggest external infection

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as the origin of iritis. It is rare for it to be actually infected with bacteria (contrary to the inference from some recent veterinary literature) and when it is infected, panophthalmitis ensues rapidly and the eye is lost.

The solvent effect of the high proportion of albumin in the aqueous during iritis, especially if hypopyon exists, seriously affects Descemet's membrane and increases the intensity of interstitial keratitis which follows iritis. The fringe of blood vessels, as aptly described by Nicolas, around the outer zone of the cornea, and called by him superficial uveitis, is marked and accentuated with hypopyon, the deeper layers of the cornea being invaded by very obvious straight blood vessels radiating from the circumference to the height of the opaque fluid behind it. This is a distinctive symptom of iritis, not invariably, but peculiarly commonly found during the course of the disease as seen during war.

Iris.—It is common for the major part of the symptoms of ophthalmitis in domestic animals to be distinctive of those of iritis, sometimes of iritis alone. Rarely, if ever, is there ophthalmitis or uveitis of any kind without iritis.

The inflammatory exudate from the iris and other parts of the uvea rapidly becomes fibrinous, especially in the horse; the peculiar dangers of iritis then develop, for the fibrin tends to bind the iris as synechiæ or attachments to the boundaries of the aqueous chamber and to destroy its function as the movable diaphragm of the eye. Occasionally there are anterior synechiæ, in which case the iris is attached to the posterior surface of the cornea: this always indicates the most serious type of uveitis, as it is consequent upon the lens and iris being pushed forward owing to effusion into the vitreous. The very common form is the posterior synechiæ, when the iris is bound to the lens. This may be partial, or complete at the edge of the pupil, or involve a part or the whole of the posterior surface of the iris, especially when there is considerable outpouring of exudate from the ciliary bodies, as occurs in cyclitis. Often the edges of the pupil are already adherent, and thereby the supply of fluid to the aqueous is cut off and the escape of this pathological exudate is prevented. When it becomes organised this retained exudate obliterates the posterior chamber.

The attachment of the iris to the lens may have one of two effects upon the anterior chamber. The latter may be made shallow, when its main source of liquid is cut off by annular or ring synechiæ at the pupil, and this may be accentuated by the bulging forwards of the iris due to high tension of the fluid imprisoned in the posterior chamber. This bulging has often been observed by the author above and on the inside of the pupil.

Opposed to the foregoing is that state in which the iris is completely attached and drawn back on to the lens, due to a complete fibrinous adhesion.

Strong mydriasis may rend the iris from these attachments, which, it should be remembered, are often limited in extent, sometimes being very small. Synechiæ are always centrally placed on the lens, as the pupil is excessively

contracted at the time they are formed. The attachment is always from the black posterior layer of the iris or corpora nigra (developing with the retina in fœtal life). The result is that the iris may be left rent with clefts and coloboma, and that black detached parts of various sizes are left on the lens in the focal area.

However much of the other inflammatory lesion may be absorbed later, pigment is never absorbed, and these black islands, often showing a white glistening base of fibrinous attachment (organised lymph fibrin) upon the lens, are diagnostic of previous iritis.

The condition of annular synechiæ is sometimes described as seclusion of the pupil, but care should be taken to ensure that contraction and immobility of the pupil are not functional by testing with atropine. It is not so common as occluded pupil, in which the whole aperture is filled by lymph which may eventually block the pupil as a dense membrane and cause blindness by its opacity. Both conditions may shut off the anterior from the posterior chamber, with the consequences already described. Occlusion of the pupil may occur rapidly or during a single attack of iritis, and, although it impairs sight, it may not lead to further progressive change. Seclusion, on the other hand, is more likely to be the result of successive attacks. It may not affect sight so much at first, but it dislocates the physiological processes of the anterior part of the eye and renders recurrence more liable.

It should be noticed here, however, that synechiæ adhesions do not, as believed for a long time, constitute an irritation in themselves and by so doing induce recurrence of the disease.

Lens.—Opacity of the lens, especially its capsule, are common sequelæ of iritis. They are due to changes of nutrition, and lens nutrition is entirely dependent upon the uveal blood supply, which becomes dislocated during iritis.

As a rule they are not readily observed symptoms during the course of the disease, for they are usually obscured by the density of the aqueous and the cornea and often blocked out from view by occlusion of the pupil.

The ciliary body.—As the ciliary body is hidden from view, and as it is practically never involved except along with the iris, cyclitis adds little to the directly observed symptoms.

The indirect symptoms due to its inflammation are of the greatest importance, however, especially in prognosis, for they are generally severe.

The onset of cyclitis is marked by a local increase of tension, œdema of the upper eyelid and pain. The pain is not only evinced upon palpebral pressure, but exists apart from such stimulation and is acute. It should not be forgotten that irido-cyclitis, and especially cyclitis, produce much pain over the eyebrows in the human subject.

Experience leads me to believe that wounds over the zygomatic ridge at the orbit, accompanied by swollen, streaming eyes, are almost diagnostic of cyclitis (if they occur in places or conditions in which disease is likely), the

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wounds being caused by the animal in a frenzy of pain at night. It may be an ordinary accidental contusion, but it may be too often regarded simply as such an occurrence.

The part played by the cyclitis in secluded pupil, and its effect upon the aqueous humour and lens, have already been described.

The chief danger from cyclitis is that the exudate from it is not only discharged into the front chambers of the eye, but also into the vitreous, producing grave consequences. If excessive, this process raises the tension of the posterior and larger media, and drives forward the lens and the iris, making the anterior chamber shallow, and disturbing image formation by each process. At a later stage it produces atrophy and collapse, to be described in the symptoms of the vitreous.

Choroid.—The choroid is likely to be involved by extension of disease from the other parts of the uvea, but the symptoms produced are neither very definite nor very easily recognised, for their recognition is dependent upon the use of the ophthalmoscope, and the use of the apparatus is neither simple nor very practicable during the phase of the disease under review. Two important features are worthy of note. The disease may arise or progress here and show little, if any, superficial symptoms, so that it forms a possible nidus during the remission of symptoms, and it is nearly always associated with retinitis, especially in the horse, owing to the physiological reasons already noted. It nearly always produces detachment of the retina by forming an exudate between the membranes.

Retina.—In all animals retinitis is commonly associated with choroiditis. It is almost invariably so in the horse, in which animal the circulatory supply is common in both structures.

As the retina is the functional and image-forming part of the eye, changes in it reduce or destroy sight. Retinitis is, moreover, a disease associated with extension from morbid conditions in the brain, optic nerve, and orbital fossa, and is especially liable to occur during toxic or metastatic infection. It is, however, rare in the early stages of ophthalmitis, for sight is rarely lost at such a period. This is strong evidence that the disease is not primarily circulatory, specific or endogenous in origin, but depends upon an external or endogenous factor.

In the later stages, especially at war, it is common. All old writers on ophthalmitis laid much greater stress upon pathology here than do the modern ones. They present pictures of serious lesions, ending up with a detached retina forming a cone still held by the apex, where it rises from the optic nerve, and based on the lens, held there by the fibres of the vitreous that go to form the suspensory ligament from the ciliary processes. They considered atrophy of the eye as the ordinary result of ophthalmia.

Similar conditions are found at post-mortem examinations of war-time cases. The lack of stress upon it in modern literature suggests that this very

serious condition has not been observed so frequently and that the disease may have developed as a different or possibly a more serious type in the past and during war. It may be that iritis was more serious during the past and during war because the causative agents were operating for a longer period and that the premonitory or early symptoms were less recognised.

Observations in the vitreous humour are dependent upon ophthalmoscopic examination, difficult at all times, owing to obscuring lesions in front of the eye, and increasingly difficult during war. The major symptom of reduced tension and size of the eye owing to contraction of organised lymph in the vitreous is, however, marked during war cases, and noticeably confined to old-standing or recurrent cases.

Sight.—Vision may be impaired by many of the pathological changes already described. Moreover, it fluctuates considerably from day to day during the course and treatment of the disease. In the early stages, contraction of the pupil, its occlusion by lymph, and opacity of aqueous and cornea, sometimes reduce sight to blindness. Retinal detachment, occluded pupil and complete cataract are, however, the chief lesions of iritis which produce loss of sight, and usually occur in later stages.

A curious point is that night blindness has never been attributed to this disease, as there appears to be no doubt that it should be. Day blindness has been credited to the obvious cause of the pupil being obscured when it is contracted to the uttermost in broad daylight or sun, generally by a central cataract. Night blindness has been attributed by Nicolas[17] to the opacities of the periphery of the lens, which renders useless the dilation of the pupil. But no one, as far as we know, has regarded its origin to what appears an obvious and common cause, viz., an immobile contracted pupil; one attached to the lens so that it cannot dilate sufficiently to admit sufficient light rays to form a distinct image in the dim light, i.e., the common symptom and sequelæ of iritis-posterior synechiæ.

The author, after an experience of approximately 2,000 cases of iritis, many of them intimately, and many of their records having been studied carefully, is confirmed in the opinion that night blindness occurs some weeks before the ophthalmitis is usually recognised under active service conditions.

How widespread, general or marked this is, is difficult to say, but it was definite and sufficient to cause camel corps commanders in Waziristan to complain about it before ophthalmitis was recognised in their units, or had ever been recorded amongst camels, as far as was known.

Course

It is not easy to advance any very definite statements upon the course of iritis. Some regard the disease as running in almost definite phases, considering that the symptoms abate and that the eye becomes more or less

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normal in seven to ten days, the disease recurring or becoming more advanced in periods from 30 to 90 days.

Certainly many of the milder cases of the semi-acute type appear to follow such a sequence, but they represent but a small percentage. Some cases are acute and progressive and continue till the eye is lost; others never show any acute inflammation and so appear to belong to the chronic type from the onset.

Both forms are unusual. It is common for the intensity of symptoms to vary and for their remission to appear complete at times.

Usually the disease tends to decrease in intensity and become chronic. Chronic cases do not show marked remission or recurrence.

One or both eyes may be affected, but it is very rare for both eyes to be affected at the same time and to the same extent. The eyes are often attacked alternately, as noted by Bayer,[5] Greenfield[14] and Percivall.

For long, recurrence was considered characteristic and diagnostic of the condition believed specific, but iritis in all animals and types tends to be recurrent, and both Nicolas[17] and Smith[13] are strong in the contention that the disease is not so recurrent as it is believed.

Many consider that ophthalmia recurs monthly. Jakob[20] says it may recur in some weeks, but it is generally some months, sometimes years. He brings to notice the point that it may recur in any form, acute or chronic, similar or not to a previous attack.

Most observers regard the first attack as the most severe or acute and that there is generally decrease in severity. This probably suffers in accuracy from generalisation.

The experience of the author is that the apparent severity of the attacks decreases as atrophy increases, and the disease gradually fades when atrophy is marked, the horse often remaining with obvious lesions and impaired sight (but sometimes improving somewhat), but working for years without attracting lay attention or showing noticeable symptoms.

Further, we are of the opinion that the disease is markedly cumulative in effect and that it appears persistent and continuous, possibly in the deeper tissues, during the apparent remissions, and that in this state it is progressive, so that when the disease recurs the serious lesions are more advanced. Raynal[17] notices that horses may go blind after remission of symptoms. Bayer[5] and Raynal[17] agree with the view that the disease subsides after atrophy. The observations of Smith,[10] made in 1896, are also in agreement. He states: "The ravages of recurrent ophthalmia are frequently checked or decreased if the lens is destroyed."

In human ophthalmology[7] recurrence is attributed to a recrudescence of the original cause and not to a persistent and possibly a specific one as is recorded in veterinary literature. Whether the cause be specific or not, or whether the course be persistent, progressive or not, important points, includ-

ing weather, catarrh and local injuries, have been overlooked in respect of recurrences.

Common " cold in the head " produces a recurrence of iritis in horses with practical certainty, and weather is even more demonstrative. When one has a number of old cases under observation for a long time one finds some of them to recur with the regularity of the seasons. With the first cold equinoctial gale, often several cases, although not associated with each other, recur at the same time.

The Chinese have known this for centuries as is shown by the old adage, that " if you send a mule by sea he goes blind."

It appears likely that many outbreaks of ophthalmia on transport ships during the Great War or at Remount Depots were solely the recurrence of camp-contracted iritis, induced by common or virulent catarrh due to cold, draughty troop decks, exposed camps, or ill-ventilated " Tween " decks.

There appears a strong probability that while the origin of recurrence is unrecognised, these cases may be confused with primary ones and etiology suffer accordingly.

There is in the features of course and recurrence some evidence that the disease commences in the front of the eye and progresses backwards. In the early stages of slight and acute cases there are frequently symptoms confined to the front part of the eye. This is not so with serious or chronic types. In the worst cases, or as a mild case gets worse, the ciliary body is involved. In the final phase, when sight is lost and the eye atrophied, the destruction is due to inflammation of the posterior parts of the eye.

Diagnosis

Diagnosis of acute irido-cyclitis should depend upon:

1. Contraction of the pupil, its resistance to reaction from light, shade and mydriatics.
2. Exudation or deposit in the anterior chamber.
3. Beam of light through the aqueous when examined by focal illumination (see symptoms—aqueous).
4. Circum-corneal injection of the deeper vessels below the conjunctiva, which are straight—not wavy, purplish, or bright red in colour; the injected vessels are not movable or rendered bloodless by palpation.
5. Injection of vessels of the deeper layers of the cornea.

Diagnosis of chronic cases.

1. Lymph or pigment remains on the back of the cornea or front of the lens.
2. Irregular, torn or attached iris.

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3. Atrophied globe to the eye with low tension. These are usually sufficient, but most authorities include:
4. Shrunken, crenated upper eyelids, with bent margin.
5. Peripheral opacity of the cornea. It should be remembered that this is normal in horses to some extent, especially at the ends of the horizontal axis.

In cases of doubt in early acute hyperæmia a test may be made by the use of adrenalin in the conjunctival sac, which will reduce the congestion of superficial vessels, but not those of iritis (Fuchs).[7] Confirmation of chronic cases can be obtained by the use of mydriatics; the immobility or slow, irregular dilation of the pupil is generally revealed at once.

Prognosis

Uveitis is the most serious disease of the eye of the horse—an opinion supported by examination of blind eyes. Its prognosis is unfavourable, for the disease is progressive, cumulative in effect, and produces permanent sequelæ, which, like the symptoms, impair and often ruin the sight.

Some observers assess the worst results very highly. Smith says: "Operating in a series of attacks, each leaving the horse worse than before, it always ends in destruction of one or both eyes."

Such judgment appears excessive. Probably a considerable number of affected horses recover. Granted that it is extraordinarily difficult to trace the subsequent history of horses dismissed from treatment in circumstances in which it occurs now, i.e., during war or partially civilised or remote countries, the obvious truth holds good in the main, that directly the war is over, war-time conditions cease: a few old cases recur, but the disease is otherwise forgotten.

In the early stages the lymph about the iris or descended into the anterior chamber may be absorbed, even as rapidly as in 48 hours, the iris recovers its contractility, the pupil dilates, after which superficial symptoms disappear and the eye becomes, in some cases, apparently normal. In many of these cases the recovery holds good. Even when there are definite adhesions between the iris and the lens, the acute transient symptoms may subside, sight may be serviceable, and the horse may work well for years.

Recovery should be accepted with great caution and accepted fully only after a considerable period, say a year, but recovery appears definite when it does occur. Bayer emphasises this after observation in a depot for recovered animals for seven years. Nicolas considers that the prognosis for primary irido-cyclitis should be more guarded than that due to local lesions. This appears to apply to the deeper forms, and with this view the author agrees. Within moderate limits, acute cases appear to be more favourable to recovery than chronic ones.

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Sequelæ

It should be remembered that the tendency in description of this disease is to follow the nature of the condition itself and to end the description of symptoms and lesions at their most cumulative aspect.

Sequelæ, on the other hand, are by no manner of means always gross or easily observed.

It is easy to distinguish the marked drooping eyelid consequent upon a shrunken atrophied eyeball. Corneal opacities are obvious for a time, but frequently, although the inflammatory changes here are permanent when organised, they are reduced by time, and the only remaining sign may be a dark scratch-like marking, the remains of an old organised degenerated blood vessel. Often the cornea only looks smoky, due to adhesion of the pigment particles, too small for recognition, unless special experience and care are used.

It is the same with iritis. When torn and irregular the sequelæ may be very obvious, but often the only signs are shrivelled, irregular-looking corpora nigra, or a very slight irregularity in the curvature of the pupil.

Pathological changes have been described fully under symptoms and diagnosis.

There appears one omission, viz., that there is a tendency for old lesions of the lens and vitreous to become the subject of osseous degeneration in long-standing recurrent cases—this, however, is not particularly marked or important.

Treatment

The author recommends the general treatment as described by Greenfield[14, 21] with the addition of a careful scrutiny for focal infection and the elimination of suppurative centres.

Conclusion

The author submits that the disease recognised as ophthalmia, moon-blindness, etc., is a uveitis, primarily an iritis, and that the evidence of war suggests that it is not a contagious and probably not a specific disease.

His experience points to the conclusion that it arises as an exogenous infection during continued cold and exposure, and that it is frequently associated with focal infection arising from preceding suppuration, such as ulcerative lymphangitis, thrush, grease, etc.

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* Translated roughly for iritis only.

THE STUDY OF COCCIDIOSIS (EIMERIA CAVIÆ [Sheather 1924]) IN THE GUINEA PIG

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PART II

The Life History

THE life history of *E. caviæ* does not differ in any important respects from the general type of coccidian life histories exemplified by Schaudinn's (1900) classical description of the life history of *Eimeria schubergi*, which infests the intestinal epithelium of the centipede, *Lithobius forficatus*. This type has been commonly used for teaching purposes, but it is open to the objection that *Eimeria lacazei, Adelea ovata* and *Barrouxia schneideri* occur in the same situation and it is difficult for the student, or, indeed, for anyone but the expert, to distinguish between these four species. The same objection applies to the various species of Eimeria in the intestinal tract of chickens, described by Tyzzer (1929).

Eimeria caviæ, on the other hand, is the only species of coccidia parasitic in the guinea pig. Almost every guinea pig is at some time or another in-

fested with it, so that it is not difficult to find in the colon of healthy guinea pigs natural infestations which are sufficiently heavy to provide all the material that students need. The overlapping infestations that naturally occur may, indeed, produce in one guinea pig alone all the phases of the life history and these are all concentrated in the colon, so that the student requires only sections of the colon of this single animal.

If infestations of this degree are not readily obtainable they can easily be produced. To do this it is only necessary to float up, on a saturated solution of sugar in water, the oocysts from the fæces of any guinea pigs that are passing them and to place these in a Petri dish containing 1 per cent. formalin to a thickness of not more than 3 mm. and when, after about eleven days at laboratory temperature, the majority of the oocysts have sporulated, to feed these with a pipette to a young guinea pig. From six to twelve days later, according to the stage of life history required, the guinea pig can be killed.

The various stages of the life history can be studied either in sections or in smears made from scrapings of the mucosa of the colon. Guinea pigs usually contain in the cæcum and colon large numbers of the large species, *Trichomonas caviæ* and also amœbæ and, in the colon, the ciliate *Balantidium caviæ*. The nematode *Paraspidodera uncinata* may also be found. Guinea pigs therefore provide abundant material for class study.

The Nucleus

Every protozoologist is aware that the greatest caution is necessary when the appearances shown by stained sections of fixed and dead material are being interpreted. Such interpretations are unchecked by experimental work and, when so protean and delicate a structure as the protozoan nucleus is being studied in stained material, a number of factors may produce artefacts which easily mislead the observer. The literature about the protozoa shows that even the most competent and experienced observers have been misled by these artefacts. So long as morphological studies of fixed and dead material are made, it is wise to remember that the staining reactions observed in such material have to-day no more validity than they had when Wilson (1928) wrote that their chief value is that they render cell components visible and discussed the reasons why they do not necessarily enable us to draw conclusions about the biological nature of the structures which they colour. It is neither necessary nor appropriate to discuss the nature of staining processes here, but, before the nucleus of *E. caviæ* is described, it is necessary to define the terms that will be used.

Wilson (1928) explains that stains used to be classified as nuclear (e.g., hæmatoxylin) and plasmatic (e.g., eosin), and that nuclear stains were often called basic, and plasmatic ones acid. Ehrlich, however, pointed out that the terms acid and basic refer, not to the reaction of the dye, but to the nature

of its colour component, so that an acid dye may have a neutral or alkaline *pH* and vice versa. The terms acid and basic were therefore proposed. Examples of such acidic dyes are methyl blue, eosin, Congo red, light green, acid fuchsin, and of basic ones, methylene blue, gentian violet, safranin, basic fuchsin, methyl green, Bismarck brown. In some dyes, such as fuchsin, the colour group may be both acidic and basic, if the chemical treatment of it is appropriate. Both nucleus and cytoplasm usually contain elements of opposite staining capacities, but in general the nucleus exhibits basophilic chromatin and oxyphilic nucleoli. This introduces the controversial question of the nomenclature of the nuclear components.

The writer proposes to adopt Belar's (1926) conception of the structural plan of the protozoan nucleus, namely, of a nucleus composed of chromatin and nucleolar substance (also called plastin or linin by other authors) which float, in the living nucleus, in a fluid karyolymph (also called nuclear sap, karyoplasma or enchylema by other authors). This karyolymph is coagulated by fixation, so that, in the dead and fixed nucleus, the chromatin and plastin seem to be embedded in it. Some protozoan nuclei also possess a nuclear membrane which separates them from the surrounding cytoplasm, but this is frequently absent from the nuclei of protozoa, and the nucleus of *E. caviæ* has no nuclear membrane. Protozoan nuclei also often contain kinetic elements, such as centrioles, which are inside or outside the nucleus and become active only when division occurs. The writer has not found any such kinetic elements in the nucleus of *E. caviæ*.

It is very difficult to define either chromatin or plastin accurately or to devise an infallible test which will distinguish between them. Frequently they are inextricably mingled in a nucleus. As Wilson (1928) explains, Flemming coined the term chromatin for a substance in the nucleus which stains readily and deeply with the stains chiefly used when Flemming wrote, namely, hæmatoxylin, carmine, safranin, gentian violet and other basic dyes, and Flemming gave the term achromatin to all other parts of the nucleus which stained lightly with these stains. Later workers thought in terms of chromatin and other structures which were basophilic, that is to say, they stained predominantly with basic stains, the chromatin being distributed in the form of granules or clumps throughout a continuous achromatic basis of the nucleus, which was oxyphilic, that is to say, it stained predominantly with acidic stains. But it was recognised that chromatin and achromatin may be different physiological states of the same substance, which changes according to changing physiological states of the nucleus, so that the appearances produced by stains change in a corresponding manner. We have, therefore, to remember, when we try to interpret staining reactions, that chromatin, although it is usually basophilic, staining predominantly with basic stains, such as hæmatoxylin, safranin, methyl green, may become oxyphilic and stain with

acidic stains and may then, if basic stains only are used, seem to have disappeared. Similarly plastin, which is usually oxyphilic, staining predominantly with acidic stains, may become basophilic and stain chiefly with basic stains. In addition to this, all these staining reactions may be appreciably altered by the chemical action of the various fixatives used and the chemicals used for differentiation of the stains. Hæmatoxylin alone may not therefore distinguish between them; and although mixtures of aniline dyes, such as Mallory's triple stain or Heidenhain's azan, may reveal the presence of two substances which seem to be different because they are coloured red or blue by these stains, we are not told by their colour reactions alone whether they are respectively chromatin or plastin.

Certain microchemical tests, such as Feulgen's reaction, have been devised to diagnose the presence of chromatin. It is also claimed that anything that is coloured green by methyl green in the presence of an acid is chromatin. These tests frequently succeed in diagnosing its presence, but, as Wilson (1928) points out, they have often failed to do this and they are, in any event, only useful when they are applied by workers who have considerable experience of their use.

It is no doubt for reasons like these that Belar (1926) states that there is no infallible microchemical test for chromatin.

We have also to remember, especially when we are using combinations of acidic and basic stains for the study of granules in the cytoplasm, the work of Fischer (1899) and Bechold (1912), quoted by Wilson (1928), which indicates that the colours produced by mixtures of basic and acidic stains are largely governed by the relative concentrations of the dyes used, by the size of the granules or other structures that are coloured by them, by the order in which these dyes are used and by their rates of diffusion. Fischer has shown that, if mixtures of an acid and a basic dye are used or even a mixture of two acidic or two basic ones, cell components may, according to their size, chemical constitution and the rates of diffusion of the dyes, take up one dye quicker than the other, but that, if the staining is continued long enough, the slower dye will overtake and mask the quicker one, so that its colour finally predominates. This probably largely explains the different colour pictures obtained with stains like Heidenhain's azan and Mallory's triple stain.

It is not surprising, therefore, that it is impossible, as Belar (1926) points out, to distinguish infallibly between chromatin and plastin. Each may, in different nuclei, or in different states of the same nucleus, mask the presence of the other, if the staining methods have been such as to make this possible. When the nucleus divides they tend to separate and perform different functions, the plastin elements behaving as the framework on which the chromatin is divided and distributed to the daughter nuclei. Their behaviour then may therefore help us to distinguish between them, but their staining reactions

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do not then cease to be open to all the limitations just described, so that great caution in the interpretation of division figures is necessary. Changes in the normal staining reactions may indeed be more likely than ever when a nucleus is in such an intensely active physiological state as it must be in when it divides. We can, it seems, do no more than exercise all the care and experience that we have and, when we are trying to identify chromosomes, we can go no further than to say that, because certain structures appear to stain and behave as chromosomes usually do, these structures probably are true chromosomes. In some protozoan nuclei, chromosomes can only be detected by stains when the karyosome divides, because in the resting nucleus their presence is masked by the intense colour taken up by the karyosome.

For much the same reasons, when we try to distinguish optically between chromatin and karyolymph, we find that here again there is, as Belar (1926) points out, no infallible test that will distinguish between them. There is also here the added difficulty that in the fluid karyolymph fixatives may produce localised coagulations which may, when they are stained, be indistinguishable from true nuclear components composed of plastin or chromatin.

When regressive stains are used, such as Heidenhain's iron hæmatoxylin and its modifications, yet another source of artefacts is introduced, because, when the stain is applied after the tissues have been mordanted, differentiation may be unequal in different parts of the preparation and deposits of the stain may be left, especially on adjacent walls of the alveoli of the coagulated karyolymph, on the nuclear membrane and similar surfaces, and these deposits of stain may very closely simulate granules of chromatin or plastin and may be indistinguishable from structures really belonging to the nucleus. The same difficulty arises when the Romanowsky stains are used, so that interpretations based on Giemsa preparations, for example, may readily include as true components of such minute structures as protozoan nuclei what are really only deposits of the stain.

It is obvious, therefore, that, if we rely only upon staining reactions, it must be only a matter of opinion which of the nuclear components observed are interpreted as being composed of chromatin, plastin or karyolymph respectively and which we regard as real constituents of the nucleus or as artefacts. So long as we have no experimental method of determining these points we can only be guided by our own experience, by the general practice of cytologists and by the behaviour of the nuclear components concerned when the cell divides. The following account of the nucleus of *E. caviæ* is thus no more than the result of the writer's own study of many preparations fixed by different fixatives and stained by different stains, progressive and regressive, differentiated to different degrees, and it is put forward only as the writer's interpretation of the appearances seen, which must await the confirmation or criticism of others who may study *E. caviæ*.

The Resting Phase of the Nucleus

In its resting phase the nucleus of *E. caviæ* has the form shown in Fig. 29 of the young female gametocyte, a form which resembles that of the nuclei of many coccidia. Its general outline is that of a pear, which is usually separated from the surrounding cytoplasm by a clear area which does not stain. This clear zone is frequently seen round the nuclei of coccidia and other protozoa and the general opinion is that it is not an artefact due to shrinkage of the nucleus and cytoplasm away from each other during fixation, but is a part of the nucleus, which is filled, in the living nucleus, with karyolymph. In the nuclei of many coccidia this clear area of karyolymph is not separated from the cytoplasm by a visible nuclear membrane and no nuclear membrane has been seen separating the nucleus of *E. caviæ* from the cytoplasm surrounding it.

The part of the nucleus which lies within the clear zone round it appears to float in the karyolymph and consists of two very distinct parts:

(1) A part which stains more lightly, being coloured grey with Heidenhain's iron hæmatoxylin, blue with Mayer's hæmalum, blue (or reddish blue if the slide has not been blued with ammonia after differentiation with hydrochloric acid) with Delafield's hæmatoxylin, and blue to purple with the anilin blue of Heidenhain's azan and Mallory's triple stains. Comparison of the nucleus of *E. caviæ* with the nuclei of other coccidia suggests that this part of the nucleus is composed of plastin, but that chromatin may be present in it in such a finely divided state that it cannot be made visible with stains.

(2) A relatively large sphere, which stains intensely with all the hæmatoxylins and resists differentiation so obstinately that it cannot be even partially decolourised. With Heidenhain's azan stain it is coloured red, presumably by the azocarmine of this stain rather than by the orange G, because it is also coloured red before the orange G and anilin blue are applied and is also red when azocarmine is used alone. With Mallory's triple stain it may stain yellow or blue, that is to say, it takes not only the anilin blue but also the orange G and acid fuchsin of this stain. It seems, however, to have a greater affinity for the anilin blue, because it is yellow only when so much of the stain has come out in the dehydration and mounting of the preparation that the anilin blue has not been able to mask the yellow of the acid fuchsin or orange G. Probably the acid fuchsin and orange G have quicker rates of diffusion than the anilin blue which only masks them when it has had a longer time to stain. These staining reactions, and also the behaviour of the sphere when the nucleus divides, suggest that the sphere is composed largely of plastin with which chromatin is so intimately mingled that staining reactions cannot distinguish it from the plastin present.

The sphere is thus clearly a karyosome in the original sense given to that term. The term was coined, as Woodcock (1912) has pointed out, to describe

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structures of this kind consisting of a plastin basis impregnated with chromatin, the view of it taken at that time being that its primary function is to store up reserve chromatin, and principally trophic rather than generative chromatin, for the use of the nucleus when it is required. By some authors (Doflein and Reichenow, 1929) such a structure is nowadays called an amphinucleolus and is to be distinguished from the Binnenkörper of some authors, which is a nucleolus composed of plastin only, and from the karyosome of some German authors which contains, in addition to plastin and chromatin, a centriole or other kinetic centre, active only when the nucleus divides. No such division centre has been found in the karyosome of the nucleus of *E. caviæ*. It has not been found possible to decolourise the karyosome of this nucleus sufficiently to reveal in it any structure at all. This is true also of the karyosomes in the nuclei of some other coccidia.

The karyosome of the nucleus of *E. caviæ* is single and is always placed at one pole of the nucleus, never at its centre. Sometimes it appears to be inset a little in the achromatinic part of the nucleus, as the karyosomes of other coccidian nuclei often are, but the nuclei of other species of coccidia often contain more than one karyosome, even when the nucleus is not dividing, and one of these may occupy the centre of the nucleus. In only a few of the hundreds of the nuclei of *E. caviæ* examined by the writer have granules been seen which simulated additional karyosomes. These granules were much smaller than the karyosome and lay in the achromatinic pear-shaped area of the nucleus, staining black with iron hæmatoxylin and red with Heidenhain's azan. It was very doubtful whether they were karyosomes at all, because they were seen only in the nuclei of well-grown female gametocytes and oocysts and were about the same size as the granules normally present (Figs. 29 and 30) in the cytoplasm of the female gametocytes, which often persist for a time in the oocyst as well (Fig. 32). These granules also stain black with iron hæmatoxylin and some of them may stain red or orange with Heidenhain's azan (see below). They can often be seen lying over the nucleus and only careful focusing shows that they are not in the nucleus, but in the cytoplasm above or below it. Sometimes, in areas of the slides in which fixation has not been quite so good as elsewhere, it may be impossible to say whether these granules belong to the nucleus or to the cytoplasm, so that they can easily be interpreted as smaller karyosomes. This error is most likely when they seem to be present in the nuclei of oocysts, which are notorious for their resistance to fixatives and stains, so that their nuclei are often distorted, or look flattened out (Fig. 31), or show various artefacts. The granules which simulated additional small karyosomes were seen chiefly in nuclei which were not well fixed and they were not frequent or constant enough to be regarded as normal features of the nucleus. The majority of the nuclei of *E. caviæ* show only one large karyosome and in this respect they differ from the nuclei of some other species of coccidia.

The second important difference between the nucleus of *E. caviæ* and the nuclei of many other species of coccidia is that its extrakaryosomatic area does not contain any of the granules or rods of chromatin, resembling chromosomes, which are so commonly present in this part of the nucleus. So common are they in the nuclei of other protozoa that the writer made a prolonged search for them. They could not be found in any of the dividing nuclei, where they would have been most evident if they had been present. They were not visible in preparations stained with Heidenhain's azan stain, in which the chromatin of the small immature gametes was picked out clearly in red on the blue ground of the cytoplasm of the male gametocyte. They could not be seen in any sections stained with iron hæmatoxylin, although many degrees of differentiation of these sections were tried in the effort to reveal them. Schellack and Reichenow (1913) stated that iron hæmatoxylin was not so reliable as Delafield's hæmatoxylin for staining the extrakaryosomatic chromatin grains in the nucleus of *Barrouxia schneideri*, but the writer's experience has been that iron hæmatoxylin, if it is properly used and is checked by varying degrees of differentiation, gives better definition of nuclear structures than Delafield's hæmatoxylin or Mayer's hæmalum. Certainly neither Delafield's hæmatoxylin nor Mayer's hæmalum revealed extrakaryosomatic chromatin grains in the nucleus of *E. caviæ*. Only when sections were so grossly overstained that the whole parasite and the surrounding tissues also were full of granules of deposited stain or when material was badly fixed and stained, was it possible to see anything resembling granules in the nucleus and even then they were not seen in every nucleus and were not constant in shape or size. Figs. 18 and 19 of merozoites fixed in formol-saline and overstained with Mayer's hæmatoxylin show the kind of appearances that can be obtained in this way. It will be seen that the nuclei appear to be full of scattered granules and do not show karyosomes at all, so that these preparations give a totally wrong impression of their real structure.

It can be stated, therefore, that the extrakaryosomatic area of the nucleus of *E. caviæ* does not contain any visible chromatin.

This search for chromatin grains served the useful purpose, however, of indicating the meaning of the different appearances that the nucleus may present in preparations stained with different stains and differentiated to different degrees. These appearances are shown in Plates I and II. Fig. 1 shows the resting nucleus of a young trophozoite stained with iron hæmatoxylin and it will be seen that the extrakaryosomatic area stains uniformly grey and contains no chromatin grains. Fig. 8 shows three trophozoites of about the same age in a section differentiated rather more and it will be seen that decolorisation of the extrakaryosomatic area of the nuclei of two of them has gone so far that the part of it nearest to the karyosome is completely decolourised and it has the appearance of a halfmoon. The nucleus of the other one appears to consist of a karyosome surrounded by a ring, simulating a

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nuclear membrane, an appearance also shown by the nucleus of some merozoites even when they are stained with Mayer's hæmalum (Fig. 12) and by some of the nuclei of the schizonts (Fig. 11). This simulation of a nuclear membrane can be ascribed either to a local deposit of stain round the periphery of the clear zone of karyolymph which surrounds the nucleus or it could be produced when the nucleus is seen at an angle different from that at which it is seen when it has the appearance shown in Fig. 1, namely, when one end of the pear is seen from above, so that the karyosome seems to lie in the centre of a darkly stained ring.

If the differentiation is taken a stage further than that which produces the halfmoon-shaped extrakaryosomatic area, appearances like those shown in Fig. 4 are obtained. This figure shows a young schizont with three nuclei. The extrakaryosomatic area of one of them is almost completely decolourised, so that it shows a very faint halfmoon-shaped extrakaryosomatic area; but this area of the other two nuclei is completely decolourised, so that it seems to have disappeared and these nuclei seem to consist of nothing but a karyosome surrounded by an unstained zone of karyolymph. Figs. 9 and 10 show the nuclei of schizonts stained in a similar way and stages of *E. caviæ* differentiated to this degree may look so different from the same stages less severely differentiated that they may appear to be different parasites. But all these appearances can be produced by varying degrees of differentiation not only in different slides stained with Mayer's hæmalum, Delafield's hæmatoxylin or iron hæmatoxylin, but in different parts of the same section and even in different nuclei in the same schizont. No doubt can possibly remain therefore that they are all produced by staining reactions and that they have no other significance.

Failure to realise the fact that staining reactions can produce such different appearances as this has led often to serious errors of interpretation of the appearances seen. An example of this is the criticism by Schellack and Reichenow (1913) of the work of Jollos (1909) on the nuclei of *Adelea ovata*. Schellack and Reichenow suggest that Jollos studied only over-differentiated preparations of the nuclei concerned and thus obtained nuclei similar to those shown in the writer's Figs. 9 and 10 of the schizonts of *E. caviæ*, apparently consisting of nothing but a karyosome with a clear halo of karyolymph. They say that they themselves obtained, by over-differentiation, nuclei of *Barrouxia schneideri* which had this appearance and they show them in their Fig. 25, which is very like Jollos's Fig. 16 and the writer's Fig. 10. Schellack and Reichenow say that, when their preparations showing this type of nucleus were restained, the extrakaryosomatic area of the nucleus was made visible and the chromatin grains normally present in it were revealed, so that Jollos's interpretation was not correct.

The description just given of the different appearances shown by the nucleus of *E. caviæ* must strongly support this view.

DESCRIPTION OF PLATES I, II AND III.

All the figures in Plates I and II were drawn with a Zeiss camera lucida. Figures 13-33 were drawn with a Leitz 1/12th inch oil immersion objective and a Zeiss x 10 eyepiece, a Zeiss microscope being used; their magnification was x 1500. Figs. 1-12 were drawn with a compensating ocular x 10, with the same objective, their magnification being x 2250. The microphotographs were taken by Mr. W. J. Smith, of this Institute, with a Leitz microphotography apparatus. The magnification of Figs. 34 and 35 is x 600, that of Fig. 36 x 130, and that of Fig. 37 x 1150.

FIG. 1.—One of the youngest trophozoites seen, formed by the shortening and broadening of the sporozoite. X 2250.

FIG. 2.—The first division of the nucleus of the trophozoite (schizont). The karyosome appears to be dividing into two unequal portions and is surrounded by a clearer area of karyolymph. The extra-karyosomatic area of the nucleus has been incorporated in the karyosome before division. X 2250.

FIG. 3.—A young schizont showing the two karyosomes formed by the first division of its nucleus beginning to elongate for the second division. X 2250.

FIG. 4.—A young schizont with three nuclei, showing that division of the nuclei is not synchronous. Two of the nuclei show only the karyosomes and the halo of karyolymph, the extrakaryosomatic areas of these nuclei having been decolourised by differentiation of the iron hæmatoxylin. The extrakaryosomatic area of the third nucleus still retains some of its stain and appears as a faint halfmoon. X 2250.

FIGS. 5, 6 and 7.—Three young trophozoites from an overstained section, showing simulation of division of their nuclei by deposits of iron hæmatoxylin. X 2250.

FIG. 8.—A schizont with three nuclei in the resting phase. X 2250.

FIGS. 9 and 10.—Two schizonts from an over-differentiated section. The extrakaryosomatic areas of all the nuclei are decolourised, so that each resting nucleus appears to consist only of a karyosome surrounded by a halo of karyolymph. Some of the nuclei show equal and unequal amitotic divisions, the divisions not being synchronous. X 2250.

FIG. 11.—A schizont just before it forms merozoites. Some of the different appearances shown by the nucleus are indicated. X 2250.

FIG. 12.—A bundle of merozoites fixed with Helly's fixative. There is no residual body (cf. Figs. 18 and 19). All the nuclei are in the typical resting phase. X 2250.

FIG. 13.—Three very young trophozoites similar to the one shown in Fig. 1. X 1500.

FIG. 14.—A mature schizont or a male gametocyte. The two are indistinguishable until more nuclei are present. X 1500.

FIG. 15.—A schizont showing the tendency towards splitting of the cytoplasm into compartments apportioned to each nucleus, which is seen in schizonts of this age in some indifferently fixed material. X 1500.

FIG. 16.—A schizont, like the one shown in Fig. 11, about to form merozoites. X 1500.

FIG. 17.—A schizont from a section overstained with Mayer's hæmalum to show the absence of granules of chromatin in the extrakaryosomatic area of the nucleus, even when this stain is liberally used. X 1500.

FIGS. 18 and 19.—Two bundles of merozoites, showing a residual body in each, from a section fixed in formol-saline (cf. Fig. 12). The nuclei are overstained with Mayer's hæmatoxylin, so that their typical structure is obscured. X 1500.

FIG. 20.—A male gametocyte with numerous nuclei, some of which are in process of becoming male gametes. X 1500.

FIG. 21.—A male gametocyte at the stage when the nuclei stain lightly, perhaps because the chromatin is evenly distributed around the periphery of each nucleus. X 1500.

FIG. 22.—A male gametocyte showing the chromatin massing along one border of the nucleus, before each nucleus forms the body of a male gamete. X 1500.

FIG. 23.—The stumpy young male gametes being formed, each from a nucleus, on the surface of the male gametocyte. X 1500.

FIG. 24.—Elongation of the male gametes. X 1500.

FIG. 25.—Mature male gametes on the surface of a male gametocyte. The flagella are not shown. X 1500.

FIGS. 26 and 27.—Two young female gametocytes, each with a single nucleus in the typical resting phase and a cluster of small, spherical granules of food material and material which will form the walls of the oocyst. X 1500.

FIG. 28.—Rather older female gametocytes from a section differentiated until the extrakaryosomatic area of the nucleus is decolourised and only the karyosome and halo of karyolymph are left. The granules in the cytoplasm of all the gametocytes except one are also decolourised. X 1500.

FIG. 29.—An almost mature female gametocyte with its single nucleus in the resting phase and its cytoplasm full of granules of food material and material which will form the walls of the oocysts. X 1500.

FIG. 30.—Drawing from a section stained with Heidenhain's azan stain. Differences in the tones of black and white indicate the colour contrasts given by this stain. In the two lower gametocytes the darker granules, which stain red with azan, are arranged in a regular row at the periphery and will form the outer wall of the oocyst; the granules in the interior of the gametocytes stain yellow with azan and will form the inner of the two walls of the oocyst. The outer wall of the uppermost gametocyte shows pieces of the outer wall of the oocyst, formed from the granules which stain red, not yet joined together. The nuclei are not shown in any of these gametocytes. X 1500.

FIG. 31.—A young oocyst with its outer wall only, formed from the outermost row of the granules shown in Fig. 30, only the inner ones, which stain yellow with azan, being left. X 1500.

FIG. 32.—An oocyst with both its walls. A few of the granules which stain yellow with azan and form the inner wall remain in its cytoplasm. The nucleus appears flattened and distorted, because the two walls hinder the entrance of fixatives and stains. X 1500.

FIG. 33.—A mature oocyst with both its walls and nucleus in the typical resting phase. X 1500.

FIG. 34.—Microphotograph of unsporulated oocysts, showing the variation in size and shape. X 600.

FIG. 35.—Microphotograph showing sporulated oocysts, each containing four sporoblasts and a residual body, 11 days after they had been floated up on sugar solution from the fæces and placed in 1 per cent. formalin at laboratory temperature. Some of them have not sporulated. X 600.

FIG. 36.—Microphotograph of a portion of the mucosa of the colon showing a very heavy infestation. Almost every cell of the epithelium of the crypts of Lieberkühn has been destroyed. Little tissue reaction is present. X 130.

FIG. 37.—Microphotograph of part of a section overstained with Mayer's hæmalum, showing an oocyst on the right with both its walls complete and, on the left, a larger oocyst with its outer wall still incomplete. The pieces which unite to form it are derived from the outer row of granules in the cytoplasm of the female gametocyte. The nucleus of this oocyst with its karyosome is somewhat distorted by the fixative. Between the two oocysts are young trophozoites. X 1150.

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PLATE I

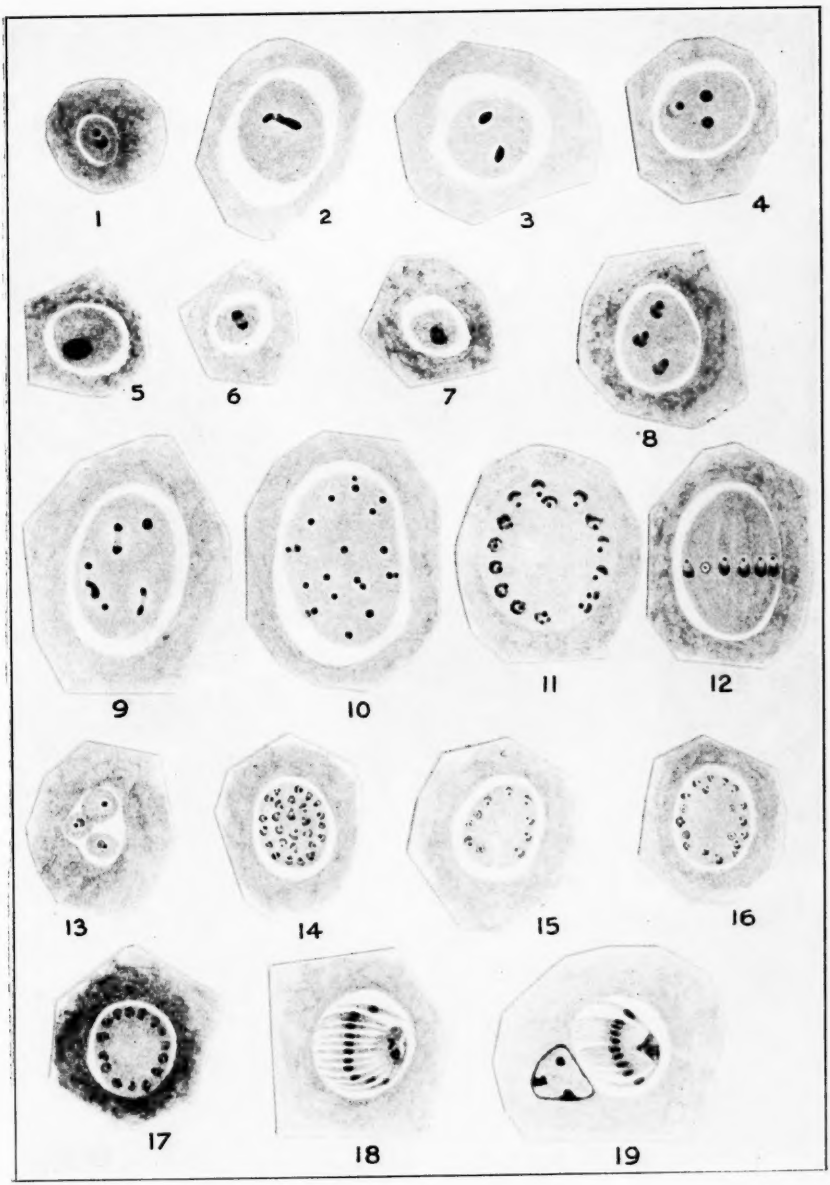
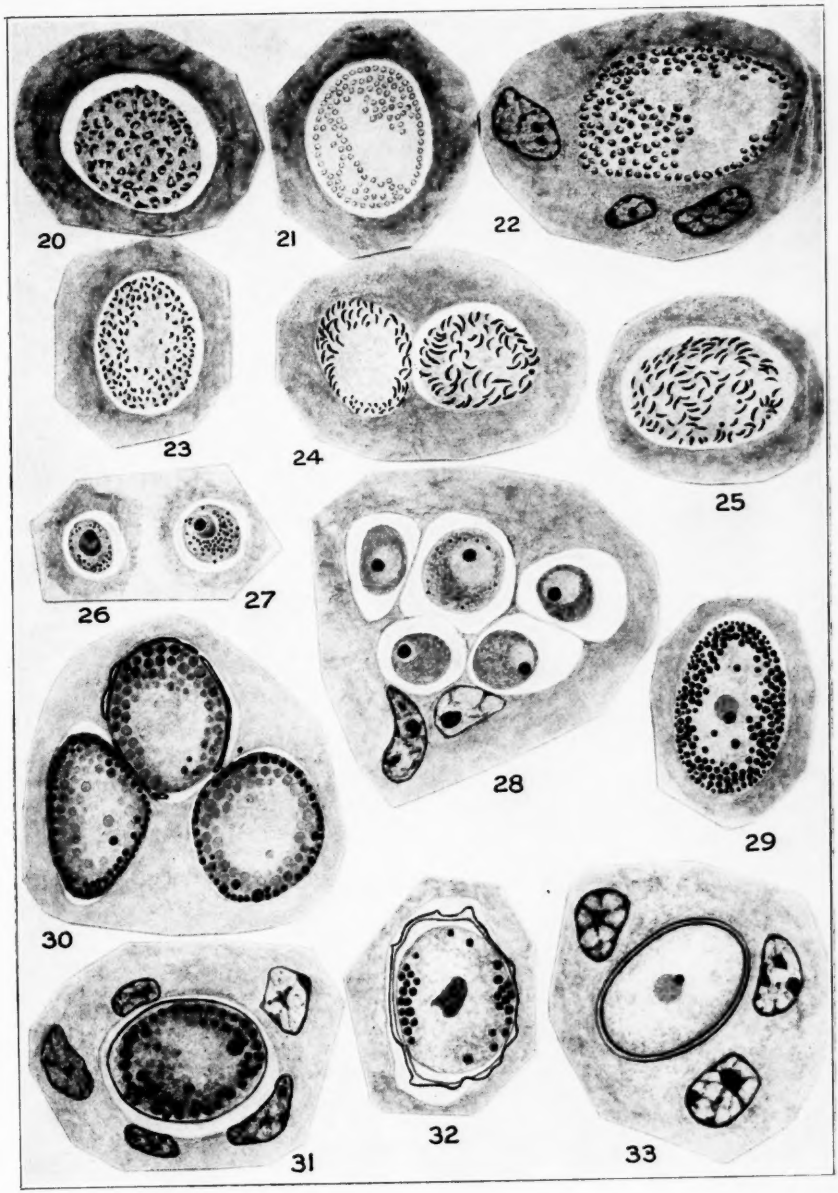


PLATE II



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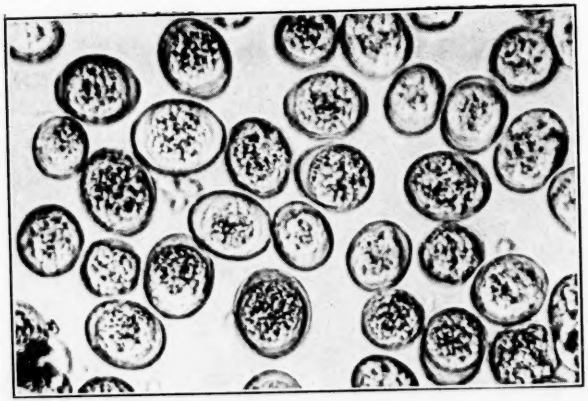

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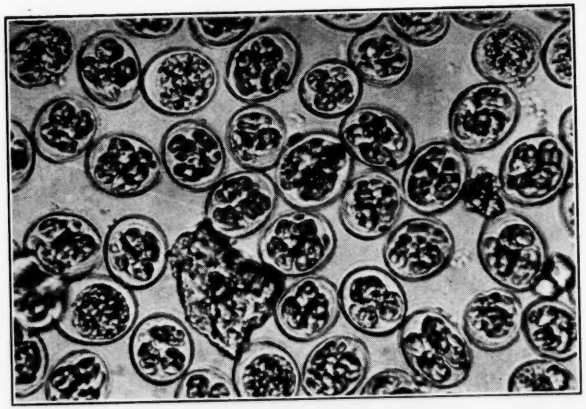

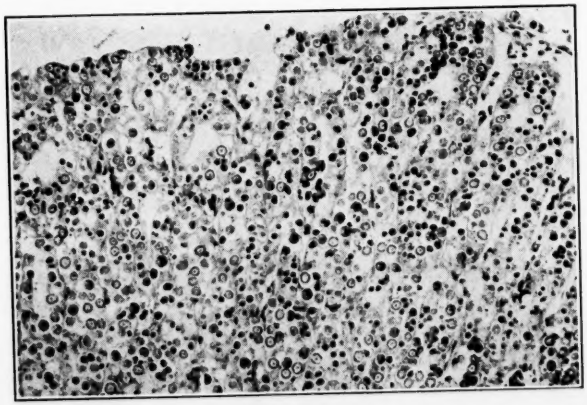

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PLATE III

The meaning of the halfmoon-shaped extrakaryosomatic area remains to be explained. A similar appearance is shown in the figures drawn by many authors who have studied coccidia. Schellack and Reichenow (1913) show it in their text Fig. 2 of the merozoites of *Barrouxia schneideri* and some of the figures in Plate 2 of their paper simulate it, if we allow for the different shape of the extrakaryosomatic area of the nucleus of this species and the presence of chromatic granules in it. The halfmoon-shaped extrakaryosomatic area can also be seen in Fig. 907f. of a young female gametocyte of *Eimeria stiedæ* given by Doflein and Reichenow (1929), a figure taken from Hartmann (1911). It is also seen in several of Swellengrebel's (1914) figures of the nucleus of *Isospora bigemina.* Simond (1897), in his study of *Eimeria stiedæ* (*Coccidium oviforme*) of the rabbit, noted and figured this halfmoon which he interpreted as a second chromatic body, thinking that it later fused with the karyosome. He thought that it occurred only in the young gametocytes and indicated the beginning of the sexual cycle. Wasielewski (1904), however, failed to obtain the halfmoon consistently in his preparations of the same parasite and concluded that it was an appearance produced by the action of fixatives. The writer, before he had seen Simond's and Wasielewski's papers, suspected, like Simond, that the halfmoon might be a means of distinguishing the schizont from the gametocyte, but later found very young schizonts which contained some nuclei with the halfmoon and others without it. This interpretation had, therefore, to be abandoned. The writer then thought that the halfmoon might be the appearance given by a stage in the division of the nucleus and that this division might be similar to the peculiar form of mitosis described by Tyzzer (1929) in the nucleus of *Eimeria tenella,* in the course of which a fan-shaped extension of the extrakaryosomatic area containing granules divides, the two halves of it moving to opposite sides of the karyosome, which then itself divides, so that one daughter fan and one half of the karyosome go to each daughter nucleus. It would be easy to regard appearances seen in some of the writer's sections as similar to the figures drawn by Tyzzer. The small karyosome of the small nuclei of the almost mature male gametocyte (Fig. 20), with its correspondingly small halfmoon-shaped extrakaryosomatic area, can, when it is distorted by fixatives or overloaded with deposits of stain, give the impression that it contains granules of chromatin and may then simulate the structures which Tyzzer found. But careful examination with higher magnifications and comparison of numbers of nuclei giving this appearance with others differently stained dispels the illusion that they represent a stage in division or that the appearance of the halfmoon-shaped extrakaryosomatic area is in any way associated with division. If any doubt of this remains in the reader's mind, it can be dispelled by the fact that the halfmoon-shaped extrakaryosomatic area is seen, when the stain is suitably differentiated, in the nucleus of the female gametocyte (Fig. 26) and also in the nuclei of the merozoites (Fig. 12), neither of which ever undergoes division. It is, moreover,

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seen in all phases of the parasite, as the figures in Plates I and II show. It is seen most clearly in sections stained with iron-hæmatoxylin, but can be produced by suitable differentiation in sections stained with Mayer's hæmalum and Delafield's hæmatoxylin. For these reasons it is obvious that it is nothing more than an appearance due to varying degrees of differentiation of different parts of the nucleus.

This conclusion leads us to the correct decision about the distribution of the chromatin in the nucleus. The extrakaryosomatic area gives clearly the usual staining reactions of chromatin and there are no visible granules of chromatin in it. We can therefore conclude that it contains chromatin in a state so finely divided that staining reactions will not make it visible except as a part of the nucleus which stains uniformly grey or blue with hæmatoxylin if the sections are stained deeply enough. If they are less deeply stained or are differentiated, some of the stain leaves the part of the extrakaryosomatic area nearest the karyosome, so that the appearance of the halfmoon is produced. The outer portion of the extrakaryosomatic area retains the stain longest against differentiation, so that we may conclude that the extrakaryosomatic chromatin is more concentrated here.

The division of the nucleus of *E. caviæ* belongs to a type which is, as Minchin (1922) pointed out, very common among the protozoa. The first thing that happens appears to be that the extrakaryosomatic area of the nucleus is withdrawn into the karyosome, so that any chromatin and plastin in it are rendered available for distribution to the daughter nuclei. The writer has been unable to see it in any of the dividing nuclei coloured by any of the stains which readily demonstrate it in the resting nucleus. It is very unlikely that it degenerates and is cast off, because no visible remains of it are ever seen in the cytoplasm of the schizont. The next stage in the division of the nucleus is the elongation of the karyosome until it assumes, by the accumulation of its substance in its two ends, the familiar dumb-bell shape (Figs. 2 and 9). In preparations stained with hæmatoxylin the two ends stain intensely black, and remain black even when the strand connecting them has been almost decolorised by differentiation (Fig. 2). When Heidenhain's azan or Mallory's triple stains are used, the swollen ends of the dumb-bell stain blue, while the connecting strand between them contains material which stains orange or red, that is to say, this material takes with these stains the same colour as that taken by the karyosome of resting nuclei and by the male gametes, which latter are mostly composed of chromatin. Reasons have been given above why we cannot conclude from these staining reactions more than that two substances are present in the dumb-bell, but it is hard to resist the conclusion that these two substances are plastin and chromatin. In the later stages nothing more happens than the elongation of the dumb-bell until the strand connecting its two ends breaks and the two ends form, by reconstruction of the extrakaryosomatic area, a pair of daughter nuclei. Throughout the division the dividing karyosome

is separated from the cytoplasm by a clear area which does not stain, so that it probably floats all the time in the karyolymph. In the earlier divisions (Fig. 2) the dividing karyosome is, of course, relatively very large in proportion to the size of the parasite, stretching almost completely across it, but in the later ones (Figs. 9 and 10) the karyosomes have become so much smaller that, when they are dividing, they look like two small dots of equal or unequal sizes lying very close together and often the strand connecting them is seen only with difficulty or not at all. Karyosomes of markedly unequal size are very often seen in the schizont (Figs. 9 and 10), and often unequal divisions of the karyosome may be seen actually in progress, so that equal division of the karyosome is by no means the rule. This is not unusual. The figure given by Jollos (1909) of the schizont of *Adelea ovata* shows karyosomes of unequal size like those shown in Fig. 10 and, whether Schellack and Reichenow (1913) are right or not in their statement that Jollos mistook this for a stage in the life history of *Barrouxia schneideri*, Jollos's figure does show well the unequal division of the karyosomes. Karyosomes probably become unequal in size because some nuclei divide faster than the others can.

Frequently in overstained sections artefacts due to deposits of stain may simulate divisions (Figs. 5, 6 and 7).

It is clear from this description that the division of the nucleus of *E. caviæ* is essentially similar to that of the nucleus of *Eimeria schubergi*, described by Schaudinn (1900), and is not essentially different from that of the nucleus of *Barrouxia schneideri*, described by Schellack and Reichenow (1913) or even the divisions of the nuclei of *Selenococcidium intermedium* and *Eimeria epidermica* described by Léger and Duboscq (1910). The differences between the divisions of the nuclei of all these species are differences of detail only, depending on differences in the structure of the nuclei concerned. In the division of all of them the principle is the same—a nucleolus composed of plastin or a karyosome composed of plastin and chromatin, elongates, assumes a dumb-bell shape and distributes its substance equally or unequally between the two daughter nuclei. If extrakaryosomatic grains of chromatin are present, these are similarly distributed to the daughter nuclei, the plastin of the karyosome acting as a carrier of them. In some nuclei the extrakaryosomatic grains of chromatin are so small that they are hardly visible, and it is not difficult to realise that the chromatin may be present in so finely divided a state that it is impossible to render it visible, so that a division would occur apparently without any chromatin grains, such as the writer has found in the division of the nucleus of *E. caviæ*. Divisions of this general type are not usually complicated by the presence of centrioles or other kinetic centres, unless we choose to regard the dividing karyosome itself as one of these. It is a matter of opinion whether we regard them as amitotic or as examples of primitive mitosis. Schellack and Reichenow (1913) class the dvision of the nuclei of *Barrouxia schneideri*, and Léger and Duboscq (1910) class the

division of the nuclei of *Selenococcidium intermedium*, both of which conform to this general type, as amitotic and there seems to be no reason to object to this view. Because the division of the nucleus of *E. caviæ* also belongs to this type, it must also be regarded as an amitotic division.

It will also be clear from this description that the division of the nucleus of *E. caviæ* bears no resemblance at all to the peculiar mitosis described by Tyzzer (1929) in the nucleus of the schizonts of *Eimeria tenella*. Tyzzer suggests that the mitosis he describes is so different from that described by Schaudinn in *E. schubergi* that the division of this latter nucleus should be reinvestigated. But, if the writer's interpretation of the division of the nucleus of *E. caviæ* is correct, the similarity between its method of division and that of the nucleus of *E. schubergi* as Schaudinn described it renders it unnecessary to doubt Schaudinn's interpretation. The mitosis described by Tyzzer is, as he himself admits, unlike any other described in other coccidia, whereas the division described by Schaudinn does not differ in principle from those described by other later authors in many other coccidia. As Minchin (1922) says, it is a method very common in the nuclei of protozoa and a study of Belar's remarkable summary of our knowledge of these will confirm this view.

(*To be continued.*)

HISTO-PATHOLOGICAL STUDIES OF SCRAPIE, AN OBSCURE DISEASE OF SHEEP

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For a description of the history, conditions of occurrence, symptoms and course of scrapie the reader is referred to published papers by Stockman (1913), M'Gowan (1914), McFadyean (1918), Gaiger (1924) and Bertrand, Carré and Lucam (1937).

1. *Macroscopic Examination*:

It is generally accepted by those who have investigated scrapie that, apart from the presence of traumatic lesions induced by the vigorous rubbing of the skin, no consistent gross pathological change occurs in the disease. This view has been confirmed by the writer's experience. Numerous systematic

post-mortem examinations have been carried out and in several cases the entire central nervous system has been minutely examined with negative result.

2. *Microscopic Examination*:

Review of the Literature.

Besnoit and Morel (1898), while agreeing that no macroscopic lesions occur in scrapie, described certain histo-pathological changes in the medulla, spinal cord and peripheral nerves. They found that the Nissl substance in the case of a number of the large neurons in the medulla and cord was disintegrated; the periphery of the cell only might be affected or the whole Nissl substance be converted into very fine granules. In the cell cytoplasm more or less voluminous " vacuoles " were found and these might displace the nucleus to the periphery of the cell. Only a few of the cells were thus affected.

The lesions in the peripheral nerves were found to be more marked than those of the central nervous system. The process began in an intense neuritis in the plantar, intercostal, zygomatic and subcutaneous nerves. The lesions were demonstrated by fixation with osmic acid. In the affected nerve fibres the axis cylinder disappeared and the myelin sheath, at first crenated on its surface, was later fragmented, then reduced to globules; finally it also completely disappeared, the neurolemma alone remaining.

In the later stages of the disease the large nerve trunks occasionally presented similar appearances, but here these were less marked than those found in the peripheral nerves.

Besnoit and Morel were accordingly of the opinion that in scrapie there exists an intense and extensive peripheral neuritis.

Cassirer (1898), quoted by Bertrand, Carré and Lucam, made an exhaustive microscopical examination of the central nervous system but failed to demonstrate any microscopic abnormalities other than those described by Besnoit and Morel; he did not, however, find any evidence of peripheral neuritis.

M'Gowan (1914) made a histological examination of the following tissues: heart, lung, œsophagus, thyroid gland, tongue, salivary glands, liver, spleen, kidney, pancreas, mammary gland, the various parts of the male and female genital organs, the urinary tract in male and female, the separate regions of the alimentary canal, each of the regions of the spinal cord, the posterior root ganglia, the sciatic nerve and portions of the brachial plexus. The muscles from various parts were examined microscopically both in teased preparations and in sections. He also examined smears from the blood, bone-marrow, spleen, liver, kidney and lungs. The only finding which he recorded as significant was the constant presence of sarcosporidia in the musculature.

M'Gowan observed that these parasites were of constant occurrence in scrapie and that they occurred frequently as a heavy infestation. He was of

opinion that *Sarcocystis tenella* represented the cause of the disease and advanced several arguments in support of this view. His conclusions have not, however, met with general acceptance. It has been known that heavy *Sarcocystis* infestations are present in sheep which show no evidence of scrapie and that particularly heavy infestations may occur in cases of debility arising from causes other than scrapie.

Stockman (1926) observed vacuolation of neurons in the central nervous system similar to those described by Besnoit and Morel, but failed to confirm the existence of a peripheral neuritis. He also observed in the neurons of the medulla, cord and spinal ganglia small bodies resembling Negri bodies. These were thought at first to be specific to scrapie, but later he found similar bodies in the neurons in a case of swingback. Brownlee and Wilson (1932) described similar bodies in the spinal ganglia in cases of louping-ill and found that they were non-specific and tended to become more numerous as the sheep advanced in age. The present author has also found similar bodies in small numbers in the neurons of the medulla and cord of sheep experimentally infected with louping-ill virus (unpublished work).

The presence of Demodex mites in the sebaceous glands of the skin in the region of the vulva and less frequently of the nostril in sheep affected with scrapie was recorded by Brownlee (1935), but was regarded as of no significance in the pathogenesis of scrapie.

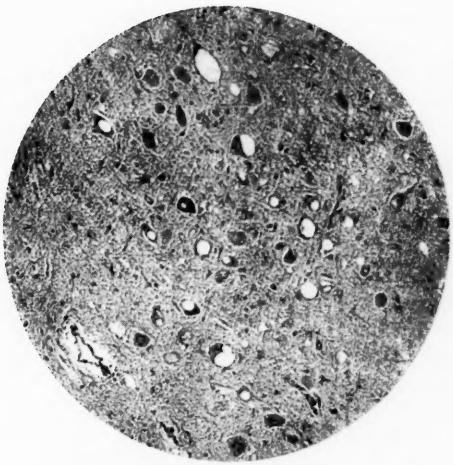
Since the completion in 1936 of the work described in this paper, Bertrand *et al.* have published the results of their investigations. They found that in addition to the vacuolation of the nerve cells there was in scrapied sheep an intense gliosis involving the grey matter of the brain-stem, and cord and to a less extent the higher centres, and they describe the disease as a subacute polio-myelo-encephalitis.

Since scrapie is a disease which, in the great majority of cases, runs a chronic course it might be expected that definite tissue reactions should develop. The work now described was initiated with the object of determining whether a systematic histological examination would reveal some definite pathological change.

The results detailed in the appendix show that no constant specific changes were demonstrated other than vacuolation of large neurons in the medulla and cord.

Twenty-four typical cases of scrapie were particularly examined for the presence of vacuolation. In all of these cases vacuoles were found to occur in neurons of the medulla and/or spinal cord.

The vacuoles appeared to be similar to those described by Besnoit and Morel, but disintegration of the Nissl substance such as is described by these authors was not as a rule found, the cells generally appearing to be healthy



Section of medulla of sheep affected with Scrapie showing vacuolation of nerve cells. x 80.

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apart from the vacuolation. The vacuolated cells were usually relatively few in number though the photographic illustration shows how extensively affected the neurons may be. The neurons are usually either extensively affected or appear quite healthy. This might suggest that the etiological factor has a selective action on certain cells. On the other hand, the distribution of the affected cells varies somewhat in individual cases. The distribution of nerve cell systems in the sheep is not yet sufficiently well known to permit the inference that selective injury has been inflicted on the cells of any particular nerve cell group or groups.

For the purpose of controlling these observations material from the medulla and/or spinal cord of 64 non-scrapie sheep, of which at least 16 were about two years old or over two years old and thus comparable in age to the scrapied sheep, was examined for the presence of vacuoles. These control sheep were suffering from various diseases, including conditions of a chronic nature, and in this respect were also comparable to cases of scrapie. In a few cases, the majority of which were sheep infected with louping-ill virus, vacuoles were occasionally observed in necrotic nerve cells present in the medulla and cord. The vacuoles here, however, differed from those present in the neurons of medulla and cord of sheep affected with scrapie in that they were much smaller in size, and occurred only in necrotic cells, whereas in scrapie the cells containing the vacuoles appeared normal apart from the vacuolation. With these exceptions no vacuoles were found in the neurons of the medulla or cord in any of these controls.

It should, however, be recorded that vacuoles similar to those found in the neurons of scrapied sheep may occur in the cells of the spinal ganglia of sheep apparently free from scrapie. In the spinal ganglia both of cases of scrapie (see appendix) and also of several of the above-mentioned controls, large vacuoles were found in a few cells. The significance of these findings is at present unknown.

Since these findings indicate that vacuolation appears to be constantly present in scrapie and since no closely analogous condition has been found in a considerable number of control sheep it is possible that such severe vacuolation is specific to scrapie.

Greenfield and Buzzard (1921) state that vacuolation of nerve cells occurs in chronic alcoholism and in scrapie also vacuolation may be due to a toxic substance acting on the nerve cells over an extended period.

The results of the examination of the peripheral nerves by Marchi's method were not sufficiently definite to warrant drawing a conclusion. By Marchi's method, artifacts are very easily produced and rather detract from the value of this method. Further disease and control material would require to be examined after staining by the Weigert Pal method before any conclusion could be arrived at regarding the changes demonstrated by this technique.

Attention may be drawn to the fact that the changes in the peripheral

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nerves, described by Besnoit and Morel, might be expected to lead to an extensive loss of sensation or of motor power, symptoms of which are frequently not observed in scrapie. The present author has not found evidence of definite loss of sensation and although partial paralysis of the hind quarters may occur in the terminal stages, there is no evidence that this is associated with degeneration of the peripheral nerve fibres.

In the other tissues examined no changes were observed which would indicate that in scrapie there is any constantly present structural change to which any specific functional disturbance could be definitely referred.

The relative numbers of sarcocysts present in the musculature of scrapied and non-scrapied sheep was estimated by counting the number present in 20 low power fields in sections of heart muscle, and muscle from the hind quarters and by counting the number in a complete section of the œsophagus.

The averages of these counts were as follows:

Heart muscle	8 scrapied sheep ...	...	13.3	sarcocysts
	14 non-scrapied sheep	...	16.4	„
Muscle from hind quarters ...	5 scrapied sheep ...	...	7.0	„
	9 non-scrapied sheep	...	18.7	„
Œsophagus	6 scrapied sheep ...	...	6.7	„
	8 non-scrapied sheep	...	4.75	„

These figures furnish no evidence that sarcocysts are more numerous in scrapied than in non-scrapied sheep.

Summary and Conclusions

(I) A histological examination of tissues from cases of scrapie has been carried out.

(II) The only constant finding was the presence of vacuoles, typically of large size, in the nerve cells of the medulla, and spinal cord.

(III) Such vacuoles were not found in nerve cells of the medulla and cord of sheep suffering from disease conditions other than scrapie.

(IV) Similar vacuoles have been found in the cells of the spinal ganglia of scrapied sheep and, in a few instances, of sheep not affected with scrapie.

(V) Sarcocysts were not found to be more numerous in scrapied sheep than in non-scrapied sheep.

Acknowledgments

Dr. J. Russell Greig, Director of this Institute, who initiated the work, has helped very materially by his guidance and encouragement.

The author also wishes to record his appreciation of the services of Mr. G. H. Annat and Mr. G. R. Knight who carried out the extensive technical work required for this investigation. Mr. Knight also prepared the photograph.

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APPENDIX

Results of the Histological Examination of Tissues from Scrapie Sheep.

CEREBRUM

*622—3 pieces examined:† a small cyst of undetermined nature found; otherwise normal.
952—stained by Weigert Pal; normal.
873, 880 and 950—normal.

CEREBRAL PEDUNCLES

880—a small area of microglial proliferation; otherwise normal.
950—normal.
952—stained by Weigert Pal; normal.

POSTERIOR CEREBRAL MENINGES

972 and 976—normal.

CEREBELLUM

873 and 880—normal.

CAUDATE NUCLEI, ANT. CORPORA QUAD., MID. CORPORA QUAD., POST. CORPORA QUAD., THALAMUS, PINEAL GLAND REGION, ANTERIOR MEDULLA

969—normal.

MEDULLA

374—a number of cells show extensive vacuolation.
873—fairly numerous scattered fibres are blackened by Marchi's method. A number of large cells show extensive vacuolation; vacuoles not blackened by Marchi's method.
874—occasional vacuolated cells.
922—many nerve cells extensively vacuolated.
950—vacuolation of considerable proportion of nerve cells.
952—stained by Weigert Pal; a few vacuoles present; otherwise normal.
970—several cells vacuolated.
972—several cells vacuolated.
976—several cells vacuolated; vacuolated cells are distributed over several areas of the section.

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* Each number represents the livestock book number of the case of scrapie from which the material was taken.

† Throughout the course of the work sections were stained by hæmatoxylin and eosin unless otherwise stated.

258—occasional much vacuolated nerve cell.
535—marked vacuolation of several cells.
626—several vacuolated cells.
627—many cells extensively vacuolated.
637—occasional vacuolated cell.
634—a few vacuolated cells.
625—vacuolated cells present. Stained by Scharlach R., the vacuoles were found not to contain fat.
636—several vacuolated cells.
711—several vacuolated cells.
256—a few cells markedly vacuolated. The cell groups near the 4th ventricle appear unaffected (these cell groups are usually affected).

CERVICAL CORD

Ram (no number)—several cells in grey matter on level with central canal vacuolated.
374—one cell at base of dorsal horn markedly vacuolated; one vessel shows fairly well-marked perivascular infiltration with lymphocytes and plasma cells.
873—a number of nerve cells extensively vacuolated on level with central canal and towards ventral horn but not in the apex of ventral horn.
880—one cell shows very small vacuole.
922—a number of vacuolated cells in grey matter on level with central canal and a few in ventral horn and base of dorsal horn; the Nissl substance of vacuolated cells not well stained.
952—stained by Weigert Pal; a few vacuolated nerve cells present; otherwise normal.
970—a few extensively vacuolated cells.
347—a few vacuolated cells in grey matter on level with central canal and towards ventral horn.
535—one vacuolated cell in grey matter on level with central canal.
627—one vacuolated cell in each ventral horn.
634—occasional vacuolated nerve cells in dorsal region of the ventral horn.
636—several vacuolated cells at the base of the dorsal horn.
Ewe (no number), 874, 972, 973, 976, 258, 625, 626, 637, 711, 256—normal.

DORSAL CORD

Ewe (no number)—two vacuolated cells in grey matter on level of central canal.
Ram (no number)—one cell in dorsal and one in ventral horn vacuolated.
873—stained by Marchi—many fibres blackened in lateral white substance of one side; a few large cells in grey matter on level with central canal markedly vacuolated.
880—one vacuolated cell in intermedio-lateral group.
922—a few vacuolated cells in intermedio-lateral group.
952—stained by Weigert Pal—normal.
970—occasional vacuolated nerve cells in ventral horn.
972—occasional vacuolated cells in the dorsal horn, in the grey matter on the level of the central canal, in the intermedio-lateral group and in the ventral horn.
976—occasional vacuolated cells at base of dorsal horn, in intermedio-lateral group and in ventral horn.
258—one vacuolated cell in intermedio-lateral group.
634—occasional vacuolated nerve cells in the intermedio-lateral group and in the ventral horn.
636—one vacuolated cell in the intermedio-lateral group.
625—two vacuolated cells in the intermedio-lateral group.
374, 874, 535, 626, 627, 637, 711 and 256—normal.

LUMBAR CORD

Ram (no number)—two markedly vacuolated cells in ventral horn and an occasional one in grey matter on level of central canal.
873—occasional vacuolated nerve cells in the ventral horn and one at the base of the dorsal horn.

880—slight round cell infiltration into ventral meningeal septum; no vacuolated nerve cells.
922—occasional vacuolated nerve cells in the grey matter on the level of central canal and in ventral horn.
952—stained by Weigert Pal; normal.
970—one nerve cell of ventral horn shows small vacuole.
267—one vacuolated cell in the grey matter on level of canal, one in dorsal horn and an occasional one in ventral horn.
627—vacuolated cells present—1 in dorsal horn, 2 on level of central canal, and 1 in upper part of ventral horn.
256—one vacuolated cell on the level of the central canal.
Ewe (no number), 374, 874, 972, 973, 976, 258, 535, 626, 634, 636, 625, 637, 711—normal.

GANGLIA

Ewe (no number)—thoracic-spinal ganglion—normal.
977—sympathetic ganglion in the region of the adrenal gland—normal; stellate ganglion—normal.
626—sympathetic chain ganglion—normal.
627—sympathetic chain ganglion—normal; mesenteric ganglion—normal; stellate ganglion—one vacuolated cell—otherwise normal; superior cervical vago-sympathetic plexus—normal; superior cervical ganglion—normal.
636—sympathetic chain ganglion—normal; superior cervical ganglia—normal.
625—mesenteric ganglion—normal.
972—many of the spinal ganglia showed occasional vacuolated cells.
976—many of the spinal ganglia showed occasional vacuolated cells.

NERVES

374—*Zygomatic*—stained by Marchi—nerve normal.
Subcutaneous—apparently normal by two Marchi methods, apparently degenerated by third.
Intercostal—Marchi—normal.
Plantar—Marchi—normal.
Median—Marchi—normal; Weigert Pal—normal.
Sciatic—Marchi—some fibres appear degenerated; Weigert Pal—normal.
Intercostal—Weigert Pal—a few fibres stained yellow.
Subcutaneous—Weigert Pal—several fibres stained yellow.
Zygomatic—Weigert Pal—several fibres stained yellow.

579—*Subcutaneous*—Marchi—fibres all blackened.
Intercostal—Marchi—normal.
Sciatic—Marchi—almost all fibres blackened.
Plantar—Marchi—normal.

580—*Sciatic*—Marchi—normal.
Plantar—Marchi—all fibres blackened.
Subcutaneous—Marchi—normal.
Intercostal—Marchi—normal.

363—*Sciatic*—Hæmatoxylin and eosin—numbers of fairly large vacuoles scattered within the nerve bundles.
Subcutaneous (region of back)—hæmatoxylin and eosin—normal.
Vagus—hæmatoxylin and eosin—normal.
Intercostal—hæmatoxylin and eosin—normal.
Median—hæmatoxylin and eosin—normal.
Plantar—hæmatoxylin and eosin—normal.

626—*Subcutaneous nerves*—hæmatoxylin and eosin—normal.
Nerve in Brachial plexus—hæmatoxylin and eosin—normal.
Sciatic—hæmatoxylin and eosin—normal.

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256—*Median*—Scharlach R.—normal.
Plantar—Scharlach R.—normal.
Vagus—Scharlach R.—normal.
Sciatic—Scharlach R.—normal.

ARTERIES

626—artery from anterior metatarsal region—normal; sub-cut. vessels—normal; carotid—normal; mammary and saphenous—normal; renal—normal.
634—aorta—normal.
636—aorta—normal.
256—carotid—normal; saphenous—normal; aorta—normal.

BLOOD

256—6 counts (weekly intervals).
Red cells, 8,010,000—11,390,000.
White cells, 6,400—10,800.
258—4 counts (weekly intervals).
Red cells, 8,720,000—12,190,000.
White cells, 9,600—14,400.
535—4 counts (weekly intervals).
Red cells, 7,130,000—9,110,000.
White cells, 8,000—16,200.
201—Giemsa-stained films—normal.
326—Giemsa-stained films—normal.

BONE MARROW

634—Giemsa-stained film preparation—normal.

SPLEEN

874, 876, 256—Giemsa-stained impression preparations—normal.

MESENTERIC GLAND

874, 876, 256—Giemsa-stained impression preparations—normal.

LIVER

Sheep (no number)—normal.
873—slight diffuse polymorph. infiltration in lobules and in portal canals.
874—slight cirrhosis.
876—many lobules show fat in cells around central vein.
881—normal.
201—cell outlines indistinct; nuclei normal; slight commencing cirrhosis.
326—focal and diffuse polymorph. infiltration into liver substance.
348—intense infiltration with polymorphs.
535—no amyloid or hæmosiderin present.

KIDNEY

874, 876, 881, 201, 326—normal.
535—no amyloid or hæmosiderin present.

STOMACH

326—small focus of polymorphs in mucous membrane; a few nematode parasites burrowing into mucous membrane.
363—macroscopic ulcers on mucous membrane (their nature was not determined).
874, 625, 256—normal.

SMALL INTESTINE

873—a few small macroscopic nodules present (their nature was not determined).
874—normal, stained, by H.E.B. Giemsa and Ziehl Neilsen.
881—normal.
625—*Duodenum and Ileum*—normal.
256—*Duodenum and Ileum*—normal.

LARGE INTESTINE

874—normal.
201—*Cæcum*—normal.
Large Colon—two foci of polymorphs found in mucous membrane.
625—*Large colon*—normal.
256—*Large colon*—normal.

OVARY

626, 627, 636, 256 and 258—normal.
299—both ovaries normal; corpus luteum present in both (the ewe was pregnant).

UTERUS

Ewe S.B. 2343, 256, 265, 266, 267, 626, 627 and 636—normal.
326—No micro-organisms demonstrated by Loeffler's stain. Cotyledon—normal.
258—small numbers of polymorphs scattered in muscular layer. No micro-organisms demonstrated by Loeffler's stain.

VAGINA

256—slight infiltration of round cells into corium; when stained by Gram's method no bacteria found.
326—small area of round cell infiltrations under the epithelium; no micro-organisms demonstrated by Loeffler's stain.
626 and 627—normal.
636—fairly large collection of lymphocytic cells and a collection of polymorphs in the muscular layer; section stained by Gram showed no bacteria.
299—a few polymorphs at parts just under the epithelium; another piece of tissue shows small numbers of round cells as a thin layer under the epithelium; sections stained by Gram showed no bacteria.
258—a thin layer of polymorph infiltration under the epithelium and sometimes penetrating among the epithelial cells.

BLADDER

Ram S.B. 2300—normal.

UTERINE TUBE

Ewe 265—normal.

THYROID

369—very cellular.
875—a crystalline substance present in some of alveoli.
Ewe S.B. 3687—parts of gland show well-marked fibrosis; whole section very cellular.
201—normal. Small piece parathyroid is also present and is normal.
347—fairly large cyst containing debris present; otherwise normal.
625—gland contains a small cyst.
Ewe S.B. 2345, 374, 876, 879, 880, 634 and 711—normal.

PITUITARY

580, 579, 874, 873, 876, 973 and 579—all three parts normal.
922—only anterior and intermediate parts sectioned. These were normal.

ADRENAL

Sheep (no number)—extensive areas of coagulation-necrosis in parts of medulla.
Ram (no number)—slight fibrosis in cortex.
370—commencing fibrosis.
Ewe (no number), 874, 880, 201, 326, 347, 711—normal.

PANCREAS

873, 874, 876, 880, 881, 201, 326, 347, 348—normal.

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PINEAL
874 and 876—normal.

Skin

VULVAR REGION
874, 881, 878, 882, 877, 873, 880, 922, 950, 326, 258—no abnormality except the presence of *Demodex* in a number of cases.

HIP
Ewe (no number)—normal.

NOSE
881, 878, 882, 880, 922, 950, 201—normal.
877—a few *Demodex* mites present.
873—a few *Demodex* mites present.

THIGH
881, 882, 877, 880, 922, 201—normal.

EYELID
878, 882, 877, 873, 880, 922, 950, 201—normal.

MAMMARY GLAND
878—normal.

MOUTH
878—normal.

ANAL REGION
877—normal.

BACK
873—subcutaneous tissues show bodies of doubtful nature, probably sarcocysts.
880, 950, 626—normal.

RUMP
873, 950, 201—normal.

OTHER REGIONS
Caudal Fold: 626—normal.
Axilla: 201—normal.
Buttocks: 326—normal.

SUBCUTANEOUS TISSUE
879—necrosis of tissue.
625—normal.
634—normal.

MUSCLE
Sections of muscle from the heart, biceps femoris and œsophagus of a number of cases did not reveal any abnormality apart from the presence of a varying number of sarcocysts.

NECROTIC MUSCLE FROM BACK
873—many polymorphs infiltrating part of tissue; no bacteria found.

Review

Practical Veterinary Pharmacology, Materia Medica and Therapeutics (1940). By HOWARD J. M. MILKS, D.V.M., Professor of Therapeutics and Director of Small Animal Clinic, New York State Veterinary College at Cornell University. Fourth edition. Pp. 620. With a chapter on Biological Therapeutics by A. Eichhorn, D.V.S., Director, Animal Disease Station, U.S. Bureau of Animal Industry. Price 35s.

THE publication of the fourth edition of this book has taken place three years after the third edition.

The opening chapters of the book on Pharmacy, Pharmaceutic Methods, Dispensing and Prescription Writing, contain much information given in a concise manner that will be of value to students.

The chapter, "Introduction to Pharmacology," is too brief to be of any real value. It seems out of place in a chapter of ten pages dealing with the basis of pharmacology to devote two pages to the history of therapeutics.

The actions and uses of drugs are discussed in 429 pages. Many drugs are dealt with fully and adequately, but others of equal importance are described very briefly. This drawback might have been reduced, to some extent, by excluding references to a large number of drugs of very minor importance. From the text it appears that the authors realise these drugs are of little importance.

The manner in which the drugs are grouped must be very confusing to many readers. For instance, the chapter on Specifics for the Alimentary Tract contains sections in the following order: (i) Stomachics, (ii) Vitamin Preparations, (iii) Digestive Ferments, (iv) Carminatives.

It seems a strange choice that results in turpentine being found neither under specifics for the alimentary tract, nor under volatile oils, nor under counter-irritants, but under the heading of Genito-Urinary Stimulants.

The chapter on Diuretics is disappointing, and the discerning reader will be surprised to find diuretin mentioned, not as a diuretic, but as a stimulant to the central nervous system.

The reference to spinal anæsthesia is to be found under the description of cocaine, and not under that of cocaine substitutes.

In places the description of the actions of a drug appear to contradict the therapeutic uses given later in the text.

The section on Biological Therapeutics contains several illustrations. It is difficult to appreciate the purpose of publishing that on page 572, which is so badly reproduced as to be completely useless.

The publishers have done their work well, the paper and printing combining to give a clear text that is pleasant to read. The binding appears good, and the book is of a convenient size to handle.

XUM

Correspondence

To the Editor, THE VETERINARY JOURNAL.

Dear Sir,—Regarding Mr. Pembrey's article in your May issue on "Hæmorrhage and Prolapse of the Uterus," I should like to offer the following criticism, embodying constructive suggestions for handling this type of case.

Firstly, the most important thing to do, in my opinion, as soon as possible, is to inject epidurally a suitable local anæsthetic. This relieves pain and prevents further straining almost instantaneously, and makes reduction a fairly simple matter in a very short time, and would make the accident of a torn cotyledon beginning to bleed most unlikely to occur.

Secondly, should such hæmorrhage occur, it is better to disregard it, as efforts to check it, as Mr. Pembrey discovered, are unlikely to succeed, and to press on with reduction of the prolapse, for the hæmorrhage will be more easily controlled by an injection of pituitary extract (post. lobe) as soon as reduction is effected. After such an injection a further prolapse will soon become impossible. I believe that suturing of the vulva after epidural anæsthesia and pituitary extract is unnecessary, though I usually put two mattress sutures across the lips to satisfy the client.

I think it should be emphasised most strongly that epidural anæsthesia has now been established as a valuable procedure for about fifteen years for both cows and mares in this type of condition, and the person who does not make use of this simple procedure is not availing himself of our modern knowledge. The same applies to pituitary extract.

Yours faithfully,

G. S. MUIR.

Greenmount,
Needham Market, Suffolk.
May 24, 1940.

"FREDDIE"

ON June 24 last year THE VETERINARY JOURNAL and the Veterinary Profession lost one of the best friends and best men it ever possessed, for on that day Sir Frederick Hobday died, worn out by the untiring and selfless work he had done. He never spared himself; he never forgot a friend; no lame dog ever appealed to him in vain; every cause which would benefit his beloved profession was assured of his full and active support. Hosts of us remember him with affection and gratitude. On this day, the anniversary of his death, he will come back to us, for he will ever remain in our memories.